CIVIL ENGINEERING

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COMPLETED GRADE-SEPARATION PROJECT IN FOREST PARK, ST. LOUIS

Volume 3 AMERICAN SOCIETY OF CIVIL ENGINEERS FOUNDED 1852 *Number 11*

NOVEMBER 1933

Among Our Writers

WALTER ATLEE received early comprehensive experience in the employ of the Pennsylvania Railroad, working up till he had charge of construction and design of masonry structures. Next he became, successively, assistant engineer of the Philadelphia Water Department and assistant engineer for the Philadelphia and Reading Terminal Railroad. In 1890 he returned to the Pennsylvania Railroad, and became chief engineer in 1898. After about 15 years of experience in responsible charge of location, design, and construction work for other railroads, he established a consulting office. At the time of his death in June of this year he was actively associated with the bridge department of the Maryland Highway Commission. He was a life-long friend of the late John C. Trautwine.

LAVERNE LEEPER received his B.S. degree in 1931 and his M.S. in 1932, both from the California Institute of Technology. In his graduate year he was an engineering assistant in the Testing Materials Laboratory and did research work in soil mechanics. He has since worked mainly in structural engineering, and is now specializing in earthquake analysis

SEARCY B. SLACK, former Bridge Engineer for the State Highway Board of Georgia, has had wide experience in highway bridge work. Funds for highway construction in Georgia have been somewhat limited so that it has been necessary to make close studies of costs.

JAMES B. HAYS, now Designing Engineer for the Aluminum Company of America, was Resident Engineer on the Calderwood Dam and on the Santeetlah hydro-electric power project. He practiced irrigation and drainage engineering in the West for 15 years and was associated with the late A. J. Wiley, M. Am. Soc. C.E., on the Melones Dam, and with the late F. C. Horn, M. Am. Soc. C.E., on many other projects.

CORNELIUS C. VERMEULE, a graduate of Rutgers University, has for many years conducted a general practice with his main office in New York, N.Y. His principal work has been in water supply, sewerage, drainage, and power plants. He has been engaged by a large number of municipal and private corporations, and from time to time by the State of New Jersey and the Republic of Cuba. He worked on the Morris Canal from 1923 to 1928, prepared complete plans for flood control of the Passaic in 1928, and served as chairman of a committee of the Merchants Association to review plans for disposal of the sewage of New York City in 1931.

RAYMOND P. PENNOYER, a graduate of Stevens Institute of Technology, has served 20 years with the Carnegie Steel Company, with the exception of 2 years in the A.E.F. His service with the former includes 12 years in the Homestead Mills involving long operating experience and supervision of a wide variety of construction work. For six years he has been in direct charge of sheet piling engineering and sales for the Carnegie Steel Company.

EDWIN D. CASSEL received his C.E. degree from the University of Pennsylvania in 1905. His experience includes about 10 years in railroad work of wide variety, about 4 years in general contracting, about 2 years as engineer for a large industrial plant in charge of all outside construction except buildings, and about 15 years as a sales engineer for road, trenching, conveying, and crushing machinery.

L. R. BOWEN, when he entered private practice in August of this year, had been for 20 years Engineer of Bridges and Buildings for the City of St. Louis. During that period he had charge of the design and construction of most of the reinforced concrete viaducts and bridges in the city, several railroad grade separations, and many hospital, market, airport, and other civic buildings. He is president of the St. Louis Section of the Society.

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Volume 3

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Number 11

Vehicular Ramps in the Chateau d'Amboise

Towers Added to a Famous French Castle in the Fifteenth Century Enclose Helicoidal Roadways

By the late Walter Atlee
Baltimore, Md.

HAVING chosen the Chateau d'Amboise, on the Loire, as his royal residence, Charles VIII of France undertook an extensive program for the enlargement and embellishment of the castle. As a part of this program two great towers were built surrounding inclined roadways so that men on horseback and noble personages in their carriages could ride from the road at the base of the promontory to the very doors of their apartments in the chateau above. With their easy incline, their arched and groined spiral ceilings, and their many windows, these towers are unique.

View of the Chateau d'Amboise from the Loire River

TWELVE miles east of the city of Tours in France, along the south bank of the Loire, at the entrance of its tributary, the Amasse, there arises from the water's edge a precipitous rocky promontory separating the two rivers.

From the presence of set stones—dolmens and cromlechs—and other unmistakable archeological indications, it is deduced that this promontory was an early Druid center or circle, established by the Gauls. To render the approach less accessible, they excavated a wide and deep moat which extends from one valley to the other. Later the site fell into the hands of the Romans, who were too expert in the strategy of war to overlook the importance of the position. It is with increasing astonishment that one traverses this old Gaulish terrain and studies it, noting the infallible *coup d'oeil* with which the Romans selected the sites for their strong military positions.

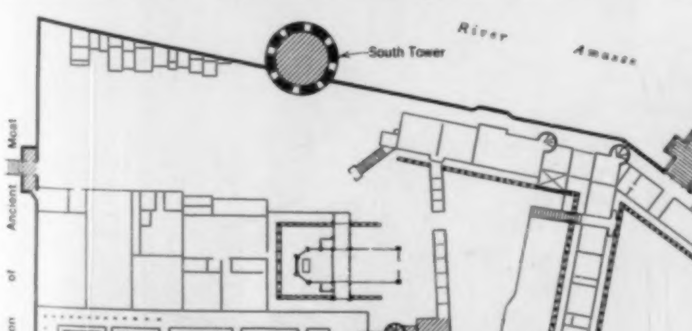
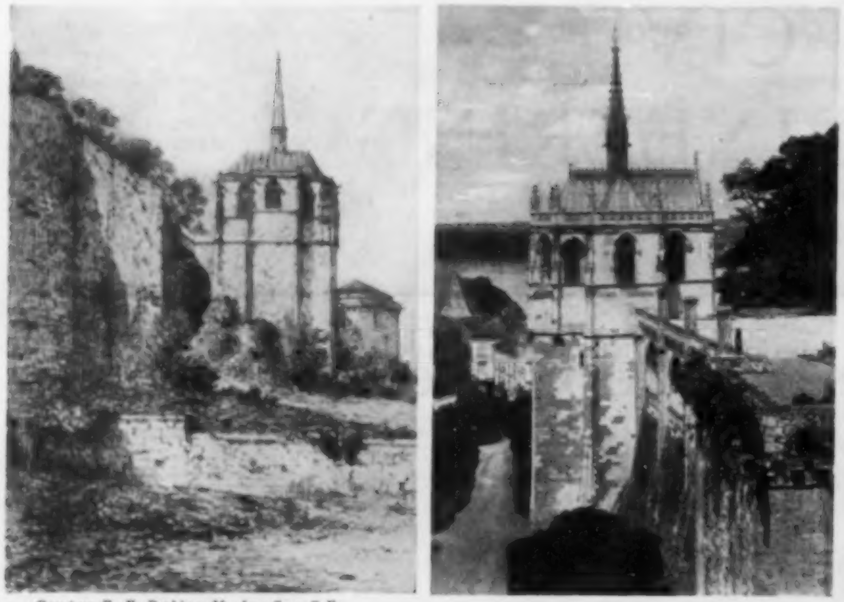


Fig. 1. Ground Plan of the Chateau d'Amboise

Strategically, Amboise has a remarkable location. It cuts in two and dominates the important valley of the Loire, which lays open the center of France and is at the same time the gate to Paris. It is about equidistant from Blois and Tours, the one to the east and the other to the west.

In 376 A. D., we hear of the first Count d'Amboise, sent by the Emperor Gratian to rule Lourraine. In 504 A. D., the famous Alaric and Clovis appeared. In the reign of the Charles the Bald, in the ninth century, the place was laid waste, and the citadel and church were burned. It was rebuilt again in the eleventh century. In the early fifteenth century it became one of the royal residences of the kings of France.

The chateau is now chiefly celebrated for two enormous round towers of



Courtesy F. E. Perkins, M. Am. Soc. C.E.

THE CHAPEL OF SAINT HUBERT, CHATEAU D'AMBOISE (1483–1498)
Leonardo da Vinci, According to Some Accounts, Is Buried Here. South Tower Appears in Left View. Relative Location of Structures Is Shown in Fig. 1

cyclopean masonry of unique construction, at least in France. They date from the reign of Charles VIII (1483–1498). These towers attained great renown not for their unusual dimensions alone, but for their ramps on easy helicoidal planes, furnishing protected passages inside the walls for engines of war, men, horses, and vehicles between the entrances at the bases of the towers and the summit of the promontory.

In the general view is shown the striking aspect of the Chateau d' Amboise from the north with its great north tower facing the valley of the Loire. This illustration, like the others not otherwise identified, and other data are taken from *Les Chateaux Historiques de la France,* by Gustave Eyriès. The ground plan (Fig. 1) gives the layout of the fortifications and the relative position of the two remarkable towers and other structures. There is also a tunnel of large cross section, some 350 ft in length, pierced by order of King Louis Philippe, connecting the entrances to the two towers, to facilitate intercourse between the inhabitants of the valleys of the Loire and the Amasse, and those living in the fortification.

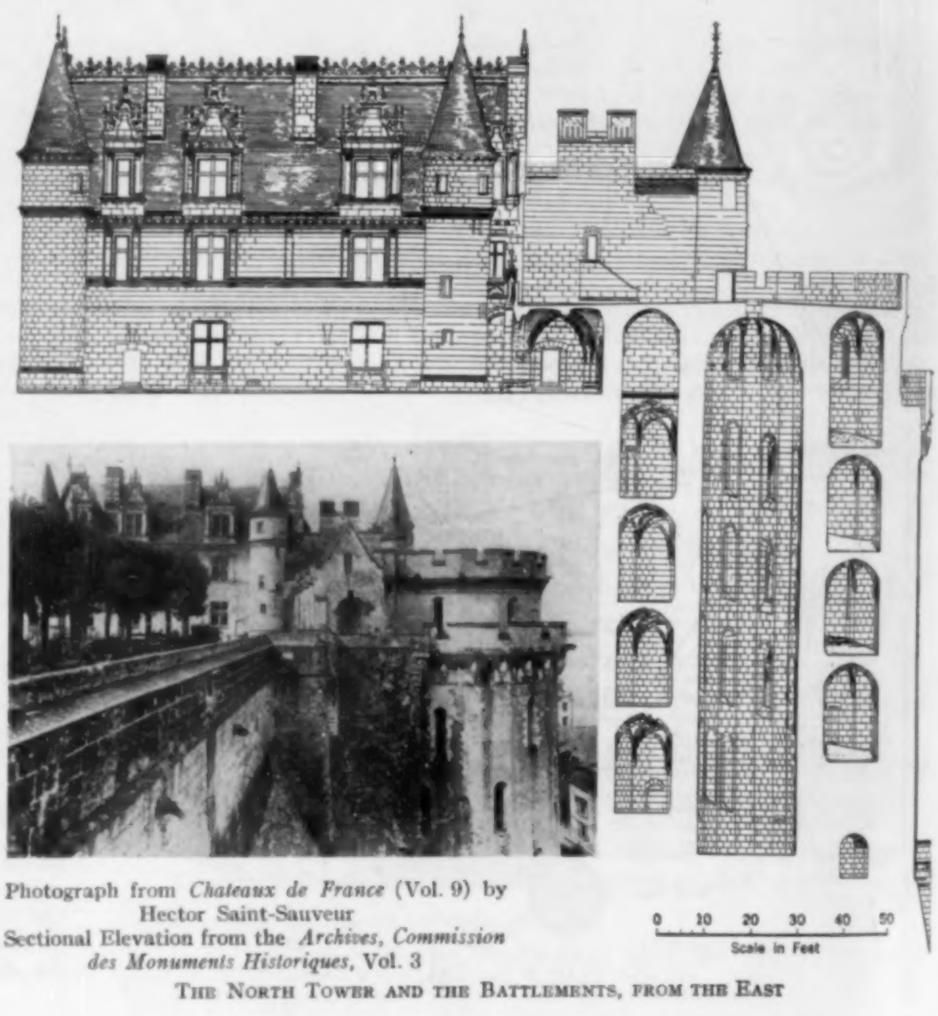
As the towers are of similar construction, a description of one will suffice. That known as the south tower being slightly larger, the more renowned, and the better preserved, will alone be given in detail. This tower, of massive masonry, is cylindrical in its exterior form and has an outside diameter of 70 ft. The exterior or enveloping wall is 9 ft in thickness. The interior surface of the wall is octagonal and is pierced by a Gothic window on each alternate side.

In the center is a smaller tower, formed by an open circular space 19 ft in diameter inclosed with a wall $5^1/_2$ ft in thickness. The interior face of this wall is cylindrical and the exterior is octagonal. The sides of the latter oppose or face the octagonal sides of the outer or enveloping wall.

On top, the wall of the interior tower terminates in an eight-sided stone cupola, arched and groined. The ribs of the arches spring from embellished corbels or medallions formed in the intersecting angles of the octagonal sides of the interior or smaller enclosed tower and converge toward a cylindrical lantern $3^1/_2$ ft in diameter, extending upward 3 ft to a skylight in the roof.

There is an open space 12 ft in width between the opposing octagonal faces of the interior tower and the sides of the exterior or enveloping tower, which extends vertically between the base and the summit of the structure.

This space encloses the celebrated so-called stepless



Photograph from *Chateaux de France* (Vol. 9) by Hector Saint-Sauveur
Sectional Elevation from the *Archives, Commission des Monuments Historiques,* Vol. 3

THE NORTH TOWER AND THE BATTLEMENTS, FROM THE EAST

stairs, a ramp most ingeniously constructed as a helix, of cyclopean masonry of easy incline [about 16 per cent], which furnishes a facile means of ascent and descent between the main entrance to the tower on the level of the valley and the stone platform of the promontory about 80 ft above, on the level of the terrace.

This ramp makes four complete helicoidal turns in its full development and generates more than 600 lin ft of passageway along its greater circumference, between the entrance and the exit. The interior views clearly show the mode of construction and embellishments, and the groined arch ceiling some 20 ft above the inclined stone floor slabs. Also, the incline itself is clearly indicated by the stone string piece, which is shown cutting across the level or horizontal courses of masonry of the side walls in the view of the interior of the north tower. The floor slabs show the converging radial lines on which the sides of the stones are necessarily cut. Their smaller or narrower ends are supported by the octagonal sides of the smaller or interior tower and the proportionally wider ends are upheld by the octagonal faces of the enveloping tower.

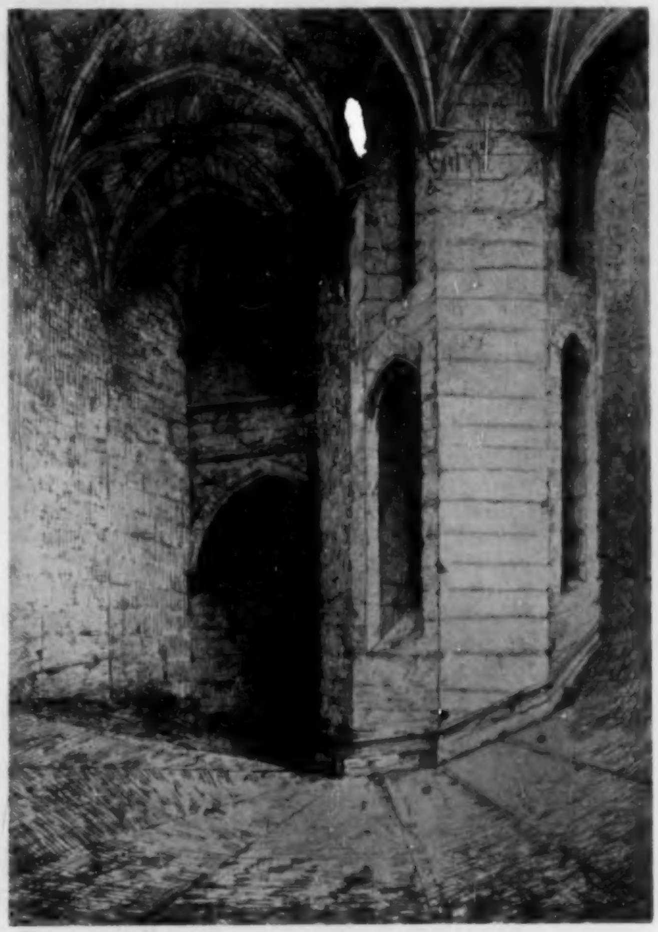
ARCHED CEILING OF HELICOIDAL FORM

In the stone-groined arch ceiling, the springing of the arches is supported by embellished stone corbels, one in each angle of the intersections of the faces of the opposing octagonal walls. The complete ramp is therefore a stone helicoidal gallery or corridor, with an elaborate ceiling some 20 ft above the floor terminating in the keystone or crown of the arch, and supporting the floor of the incline immediately above.

On completion of its first ascending turn, the ramp is directly over the main entrance at the base of the tower; on completion of the second, it is directly over the first; and so on until, at the completion of its fourth and last turn, it reaches the level of the chateau above.

Interior of the South Tower
Ramp Rises to the Right

By day the ramp is completely illuminated by windows pierced through the outside wall in each alternate octagonal face, and also indirectly, through windows in every other face of the octagonal sides of the inside wall. These windows open on the shaft within the little central tower, which is capped by a cupola and skylight. The windows occur in alternate faces of the wall, so that the light from each is reflected by an unbroken surface opposite: thus no part of the passageway is in shadow at any time during the day, as shown in the various illustrations. The sectional view of the north tower shows many features of the design and construction of this unique architectural and engineering achievement.



Interior of the North Tower
Construction Features Clearly Shown; Ramp Rises to Left

HISTORY CONNECTS LEONARDO DA VINCI WITH AMBOISE

Amboise has still other fascinations for the engineer. According to tradition it is the last resting place of one of the most famous artists and engineers of history, Leonardo da Vinci. It is known that he spent his last days in France—near this chateau—under the patronage of Francis I. He died in 1519. His body is believed by some to be buried at the chateau within the late-Gothic Chapel of St. Hubert. This beautiful but tiny structure seems all the more delicate because of its inclusion in a castle of such massive proportions.

Design of Cylindrical Concrete Tanks

Slide-Rule Formulas for Accurate Stress Analysis of Tanks with Fixed Bases

By LAVERNE LEEPER

DESIGNER IN OFFICE OF OLIVER G. BOWEN, CONSULTING ENGINEER
LOS ANGELES, CALIF.

ALTHOUGH the rigorous mathematical solution for the design of a cylindrical reinforced-concrete tank is complicated, approximations can be made that will simplify the formulas and enable the use of the slide rule to obtain a reasonable degree of accuracy. In this article Mr. Leeper gives the derivation of the stress formulas based on exact theory and then introduces modifications to simplify these formulas and make them more usable. Engineers who have tank stresses to calculate will find much of interest and profit in Mr. Leeper's solution and the specific examples he includes.

TANKS circular in plan are theoretically the most economical that can be designed, since their cross-sectional area is greater than that of any other geometric shape having the same perimeter. Such tanks, however, must withstand circumferential stress, while those having wall segments straight in plan, such as rectangular tanks, are designed to resist internal or external pressures by the resistance to bending of their component parts. If the wall of a circular tank is rigidly fixed at the base, the restraint will cause a cantilever action, which will exist in addition to the regular circumferential or "ring" action. It is this cantilever effect which complicates the design of cylindrical concrete tanks with a fixed base.

Several methods of design have been developed which take into consideration both the cantilever and ring effects. Most of them make use of tables, curves, or equations that call for considerable labor in their application. Others have been derived by approximate analyses in an attempt to produce easily used results. Some designers have rejected all such theoretical data and make use of various rules of thumb. In this article an attempt has been made to keep the analysis rigorous, and yet to produce results that can be very easily and quickly used in design. The analysis is complicated in its mathematics, but the proper approximations in the final steps give the desired simplification without material loss of precision.

A tank of the type considered in this analysis is sketched in Fig. 1. It is assumed that the floor and side wall are cast integrally and that the tank wall behaves as a homogeneous elastic cylinder fixed at the base. The symbols for the three constants of any tank are as follows:

d = height of tank, assumed to be also the total depth of water

R = radius of tank to center line of wall when tank is empty

t = thickness of tank wall, an assumed constant

The other symbols used in this analysis are:

x = vertical distance from the origin to any point, when the origin is taken at the base of the tank wall

y = total change in length of radius at height x

w = weight of 1 cu ft of water

p = intensity of water pressure at height x, equal to $w(d - x)$

p_1 = part of p that is resisted by cantilever action

p_2 = part of p that is resisted by ring action

M = internal moment on a horizontal wall section having a width of unity, considered at a height x, and taken about the center line of the wall

I = moment of inertia of a horizontal wall section having a width of unity, considered at a height x, and taken about the center line of the wall, I being taken as $\frac{t^3}{12}$

E = modulus of elasticity for concrete, assumed to be the same in the horizontal and vertical directions

C_1 = a constant, equal to EI

μ^4 = a constant, equal to $\frac{Et}{C_1R^2}$

RIGOROUS SOLUTION IS COMPLICATED

The tank wall may be considered to consist of a series of circumferential rings restrained by vertical cantilevers. The total water load carried by the wall is represented by the triangle OPQ in Fig. 1. Under this loading the wall will assume some such elastic curve as OT. The intensity of the horizontal load at any height, x, necessary to produce this curvature in the cantilevers may be called p_1. From the theory of the elastic curve it can be shown that

$$p_1 = EI\frac{d^4y}{dx^4} \quad \ldots\ldots\ldots [1]$$

The intensity of horizontal load necessary to produce the accompanying change in the length of the circumferential rings at the height x may be called p_2. The theory of thin-walled cylinders shows that

$$p_2 = \frac{tEy}{R^2} \quad \ldots\ldots\ldots\ldots [2]$$

It is assumed in this analysis that the entire water load is carried by the two effects which have been outlined, cantilever and ring action. Therefore, at the height x the sum of p_1 and p_2 must equal p, the intensity of the total water load at that height. Using the expressions previously given for p_1 and p_2, it is seen that

$$p = EI\frac{d^4y}{dx^4} + \frac{tEy}{R^2} \quad \ldots\ldots\ldots [3]$$

Substituting the constants C_1 and μ^4, which have been defined, the differential equation becomes as follows:

$$\frac{p}{C_1} = \frac{d^4y}{dx^4} + \mu^4 y = \frac{w(d-x)}{C_1} \quad . \; . \; . \; . [4]$$

This same equation has been derived in detail by B. A. Smith, M. Am. Soc. C.E., in Vol. 83 (1919–1920) of TRANSACTIONS, page 2027 et seq. As given by Mr. Smith, the general solution of the differential equation is:

$$y = \frac{pR^2}{Et} + e^{\frac{\mu x}{\sqrt{2}}}\left(A \cos\frac{\mu x}{\sqrt{2}} + B \sin\frac{\mu x}{\sqrt{2}}\right) + e^{\frac{-\mu x}{\sqrt{2}}}\left(C \cos\frac{\mu x}{\sqrt{2}} + D \sin\frac{\mu x}{\sqrt{2}}\right) \quad . \; . \; . [5]$$

The arbitrary constants are determined by the end conditions at base and crest. For a tank with base encastré the constants are:

$$A = 0 \; . \; . \; . \; . [6a] \qquad C = -\frac{wR^2d}{Et} \; . \; . \; . \; . [6c]$$

$$B = 0 \; . \; . \; . \; . [6b] \qquad D = \frac{wR^2}{Et}\left(\frac{\sqrt{2}}{\mu} - d\right) \; . \; . \; . [6d]$$

Equation 5, in the form, $y = f(x)$, is the equation of the elastic curve. By successive differentiation, it is possible to secure expressions for many other relationships. Since A and B are both equal to zero the various derivatives are:

$$\frac{dy}{dx} = \text{slope} = -\frac{\mu}{\sqrt{2}} e^{\frac{-\mu x}{\sqrt{2}}} \times\left[(C - D) \cos\frac{\mu x}{\sqrt{2}} + (C + D) \sin\frac{\mu x}{\sqrt{2}}\right] . \; . [7]$$

$$EI\frac{d^2y}{dx^2} = \text{bending moment} = -\mu^2 e^{\frac{-\mu x}{\sqrt{2}}}\left(D \cos\frac{\mu x}{\sqrt{2}} - C \sin\frac{\mu x}{\sqrt{2}}\right) . \; . \; . \; . \; . [8]$$

$$EI\frac{d^3y}{dx^3} = \text{shear} = +\frac{\mu^3}{\sqrt{2}} e^{\frac{-\mu x}{\sqrt{2}}} \times\left[(C + D) \cos\frac{\mu x}{\sqrt{2}} - (C - D) \sin\frac{\mu x}{\sqrt{2}}\right] . \; . [9]$$

$$EI\frac{d^4y}{dx^4} = \text{load} = p_1 = -\mu^4 e^{\frac{-\mu x}{\sqrt{2}}}\left(C \cos\frac{\mu x}{\sqrt{2}} + D \sin\frac{\mu x}{\sqrt{2}}\right) . \; . \; . [10]$$

The curve for Equation 10 can be plotted by assuming various values of x and solving for the corresponding values of p_1. The horizontal distance from the curve to the vertical axis at any height, x, gives the intensity of the load p_1 at that height. This load, p_1, is that part of the total load which is resisted by cantilever action. It has been assumed that the remaining part of the total load is carried by ring action. Therefore, p_2 at any height, x, is the algebraic difference between p and p_1, and is indicated by the horizontal distance at that height between the plotted curve and the straight line representing the variation of the total water load.

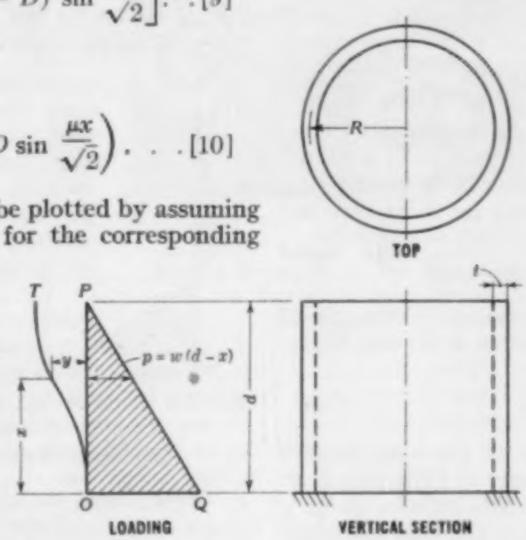


FIG. 1. LOAD DIAGRAM AND DEFLECTION CURVE FOR THE WALL OF A CYLINDRICAL CONCRETE TANK WITH A FIXED BASE

A typical curve obtained by plotting the equation for p_1 is shown in Fig. 2. It crosses the vertical axis at some height, a, and comes back to it at some point above. If the tank is very deep, the curve may cross and recross the axis several times in an oscillatory manner. The frequency of the oscillations is constant, but their amplitude decreases rapidly as the value of x increases.

To design the tank wall for ring action, the oscillations above the height a may be neglected. The curve from the place where p equals wd at the base, up to the point where it crosses the axis at height a may be assumed to be a straight line, as shown by the dotted line, QS, in Fig. 2. Then the load that must be carried by ring action is represented in Fig. 2 by the triangle PQS. At any height, x, the value of p_2 is equal to the horizontal dimension of the triangle. When p_2 is known, the unit circumferential stress at that height can be found from the expression, $\frac{p_2R}{t}$, and the necessary amount of steel can be easily determined. An expression for the critical height, a, is next developed.

Equations 8 and 9 may be plotted in the same manner as Equation 10. Diagrams are obtained, respectively, for the bending moment and shear due to p_1. Typical curves for all three equations are shown in Fig. 3. The shear curve crosses the vertical axis at some height, b, which is below a. At a the shear curve reaches a maximum. The bending-moment curve crosses the axis at some height, c, which in turn is below b. At b the bending-moment curve reaches a maximum. From an inspection of the diagrams in Fig. 3 and Equations 7 to 10, inclusive, it is apparent that

$$x = a \text{ when } EI\frac{d^4y}{dx^4} = 0$$

$$x = b \text{ when } EI\frac{d^3y}{dx^3} = 0$$

$$x = c \text{ when } EI\frac{d^2y}{dx^2} = 0$$

$+M$ is maximum when $x = 0$ in Equation 8

$-M$ is maximum when $x = b$ in Equation 8

Shear is maximum when $x = 0$ in Equation 9

As has already been noted, it is necessary to know the value of a to design the steel for ring tension. The value of c and the magnitude of $+M$ and $-M$ are needed in the design for cantilever action. The maximum shear is required to calculate diagonal tension, which may determine the thickness of the tank wall.

Assuming that $EI\frac{d^4y}{dx^4}$ is equal to zero, and expressing all constants in terms of the three tank constants, it is found that

$$x = a = 0.76\sqrt{tR} \times \tan^{-1}\left(\frac{d}{d - 0.76\sqrt{tR}}\right) . \; [11]$$

The last term in the denominator of the arc tangent is small and may be neglected without serious error. The angle then becomes 135 deg and a equals $1.79\sqrt{tR}$. Actually, the angle will always be slightly less than 135 deg, so that a closer approximation is

$$a = 1.75\sqrt{tR} \quad \ldots\ldots [12]$$

Assuming that $EI\dfrac{d^2y}{dx^2}$ is equal to zero and expressing all the constants in terms of the three tank constants, it is found that

$$x = c = 0.76\sqrt{tR} \times \tan^{-1}\left(\frac{d - 0.76\sqrt{tR}}{d}\right). \quad . [13]$$

Since the last term in the numerator of the arc tangent is small, it also may be neglected without serious error. The angle then becomes 45 deg and c equals $0.6\sqrt{tR}$. Actually, the angle will always be slightly less than 45 deg; therefore a closer approximation is

$$c = 0.56\sqrt{tR}. \quad \ldots\ldots [14]$$

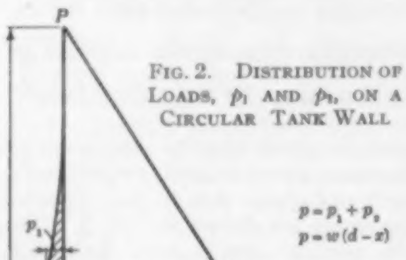


FIG. 2. DISTRIBUTION OF LOADS, p_1 AND p_2, ON A CIRCULAR TANK WALL

At the base, where x is equal to zero, the positive bending moment is greatest. By expressing all the constants in Equation 8 in terms of the three tank constants and taking x equal to zero, the expression can be reduced to the following simple form:

$$M = +18\,Rt\,(d - 0.76\sqrt{tR}) \quad . \; . \; . [15]$$

When x equals b, the negative bending moment is at a maximum. The value of b is small for tanks with small values of R and t, and large for those with large values of R and t. Therefore the factor $\dfrac{\mu x}{\sqrt{2}}$, or $\dfrac{x}{0.76\sqrt{tR}}$, which appears in Equation 8, is a ratio essentially constant for all tanks when x is equal to b. This factor b was evaluated for several different tanks by considering Equation 9 equal to zero and solving for b for each set of tank constants. The ratio, $\dfrac{b}{0.76\sqrt{tR}}$, was found to be almost exactly 1.5 for each tank. The angle of 1.5 radians is 83.5 deg but if it is taken as 90 deg, Equation 8 becomes

$$M = -4\,Rtd. \quad \ldots\ldots [16]$$

Horizontal shear, V, is greatest at the base when x is equal to zero. If all the constants of Equation 9 are expressed in terms of the three tank constants and x is taken equal to zero, it is found that the expression reduces to the following simple form:

$$V = -25\sqrt{Rt}\,(0.76\sqrt{Rt} - 2d) \quad . \; . [17]$$

Equations 12, 14, 15, 16, and 17 give the factors necessary in design. It should be noted that when R, t, and d are expressed in feet, these equations give a and c in feet, $+M$ and $-M$ in foot-pounds per foot of wall, and V in pounds per foot of wall. To illustrate the use of the equations, numerical examples have been prepared for three different tanks. For convenience, the results are arranged in tabular form (Table I). To show the accuracy of Equations 12, 14, and 16, which involve approximations, the exact solutions for a, c, and $-M$ have been found by Equations 11, 13, and 8, respectively. The error involved, in percentage, is given in Table I.

For the tanks used in the numerical examples, the constants are as follows:

TANK 1	TANK 2	TANK 3
R = 5 ft	R = 9 ft	R = 15 ft
t = 0.75 ft	t = 0.75 ft	t = 1 ft
d = 10 ft	d = 20 ft	d = 30 ft

As given in Table I, the data derived from Equations 12, 14, 15, 16, and 17 are sufficient to design the circumferential and cantilever steel and to investigate the wall for diagonal tension. Although Equations 12, 14, and 16 involve approximations, the table shows that they are sufficiently accurate for most uses. It also shows that

TABLE I. COMPARISON OF EXACT AND APPROXIMATE SOLUTIONS OF STRESSES FOR DESIGNING CANTILEVER AND CIRCUMFERENTIAL SHEAR STEEL

TANK NUMBER	VALUE OF a			VALUE OF c			VALUE OF $+M$	VALUE OF $-M$			VALUE OF V
	Exact	From Eq. 12	Error in %	Exact	From Eq. 14	Error in %	From Eq. 15	Exact	From Eq. 16	Error in %	From Eq. 17
1	3.36	3.39	0.9	1.04	1.09	4.8	575	140	150	7.1	900
2	4.56	4.55	0.2	1.45	1.46	0.7	2,190	516	540	4.7	2,470
3	6.77	6.78	0.15	2.15	2.17	0.9	[illegible],290	1,720	1,800	4.7	5,520

they are more accurate for large than for small tanks. For $-M$, in the value of which there was the greatest percentage of error, the approximation is on the safe side. The assumptions made in the last part of the analysis are to render the expressions as simple as possible. All terms involving arc tangents and e to various powers have been eliminated to obviate the use of tables. A slide rule is all that is required. If a higher degree of accuracy is desired, the more rigorous expressions—Equations 11, 13, and 8—can be used. They not only require the use of tables but also take considerably more time than the simple expressions derived from them.

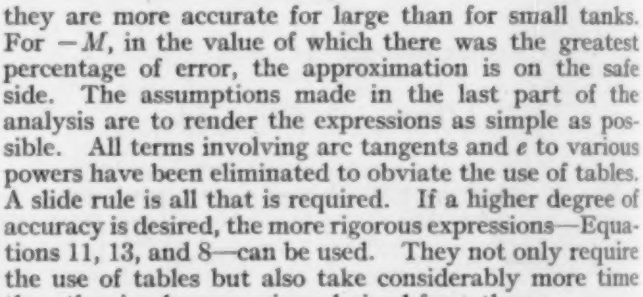


FIG. 3. DIAGRAM OF LOADS, SHEAR, AND BENDING MOMENT FOR THE WALL OF A CYLINDRICAL TANK

Expressed by Equations 10, 9, and 8, Respectively

Throughout the analysis it has been assumed that the thickness of the tank wall is uniform from top to bottom. Actually the wall may be reduced in thickness above the height a without materially affecting the accuracy of the results.

Low-Cost Highway Bridges

Use of Continuous Beams, Rigid Frames, Open End Bents, and Combinations of Wood, Steel, and Concrete Prove Economical

By Searcy B. Slack

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Many cogent arguments in favor of building highway bridges of simplified design and economical materials are given by the author of this article. He advocates selecting the proper type of bridge to fit the site, but because of possible changes in highway location or in loads and density of traffic to be carried, he questions the useful life of many so-called permanent structures. As trestle-type bridges are adequate for most highway crossings, he recommends for consideration a type of construction consisting of creosoted wooden pile bents, steel joists, and concrete floor. A service life of from 30 to 35 years for this type introduces but a slight burden for renewal charges. The saving in cost of open-type end bents as compared with solid masonry abutments is pointed out. Where conditions justify, advantage should be taken of the economy inherent in continuous-beam, rigid-frame, and cantilever types of construction. Mr. Slack's recommendations are based on his experience on state highway bridge work in Georgia, and this article has been prepared from a paper read before the Highway Conference at the University of Michigan.

During these times of economic stress the question of cost in every field is being very carefully considered. In highway and bridge work high standards of construction and traffic service have been set, and the public has been taught to expect this service. To lower these standards or reduce the service would be a step backward. Therefore the problem at this time is to maintain the present standards of construction and service in spite of reduced revenue.

Discussion of possible methods of reducing the cost of bridges is peculiarly timely just now. The following methods suggest themselves: (1) reduction in length of structure or foundation cost; (2) reduction in width of roadway or design load; and (3) simplification of design and economy in the selection and use of materials.

The folly of building bridges with poor foundations, or bridges that are inadequate to pass the reasonably expected stream flow, was long ago demonstrated, so the first suggestion may be eliminated without serious consideration.

Stream-line car bodies and the increasing power of motors indicate that the trend in traffic development is toward higher speeds and heavier loads. To reduce the width of roadway or the design loading would be directly to oppose these developments. Narrow roadways for high-speed traffic are dangerous, and light bridges are a handicap to the development of any highway. The second suggestion therefore sacrifices safety and seriously limits the future usefulness of the highway.

Simplification of design and the economic use of materials seem then to present the only possibilities in the development of low-cost bridges. Since the term, low-cost bridge, is strictly relative, any discussion of this subject involves the comparison of several designs. From such a comparison a decision must be reached as to which design is best suited for the location in question. First cost and maintenance are factors that must be considered. Generally the same engineering staff is in charge of both construction and maintenance, and is reluctant to recommend any type of construction—however low the first cost—that will involve high maintenance cost. This article deals primarily with short-span or multiple-span bridges of the trestle type, since most bridges belong in this class.

For the public the most economical bridge is that on which the total cost is the least when first cost, maintenance, renewal, insurance, cost to traffic, and all other charges incidental to the structure are considered. In his book, *Economics of Highway Bridge Types*, C. B. McCullough, M. Am. Soc. C.E., has developed a formula which states that the total annual cost is equal to the first cost, times the rate of interest on the investment, plus the average annual maintenance cost, plus the renewal charge, plus the insurance charge, plus the operating cost. He reduces this cost by a factor, p, which he defines as the per cent of the first cost that is a gain to the community or state in the development of scenic resources, in advertising the community or state, in the enhancement of abutting property values, or in similar ways. This reduction is such an intangible factor that it is difficult indeed to evaluate. However, it must be considered in order to justify, from an economic standpoint, the construction of certain types of bridges in certain locations. It is a factor that involves fitting the bridge to the location.

Combination Highway Bridge in Georgia

Treated Timber Bents for Approaches; Concrete Piers for River Span; Steel Joists for Floor System; Concrete for Deck and Guard Rails; and Open End Bents for Abutments with Riprapped Approach Fills

It is obvious that the same economic measures cannot be considered in designing a bridge for beautiful natural surroundings or for a park, as in designing it for a long swampy stream crossing where the substructure will rarely ever be seen. An unsightly structure in

beautiful natural surroundings is an anomaly, and sooner or later there will be a public demand for its replacement even though it may still be serviceable. This is the factor that rightly should be included in evaluating a structure.

The first cost and rate of interest to be charged on the

GEORGIA HIGHWAY BRIDGE IN A NATURAL PARK NEAR A SMALL TOWN

Here Appearance Is a Governing Factor in Design

investment can be closely estimated. The maintenance costs, renewal charges, and insurance charge are items that vary widely with the different types of construction, and each of them will be considered separately for the different types of materials.

OPERATING COSTS AND RENEWAL CHARGES

The operating cost, or the cost to traffic of driving over a structure, will be about the same on any well-constructed, properly surfaced bridge. The difference in the cost of operating a vehicle on a bituminous mat or asphalt placed on a creosoted timber floor as compared with the cost of operating the same vehicle on a concrete slab is very slight. On the other hand, there would be an appreciable difference in the vehicle operating cost on a rough timber floor as compared with that on a concrete slab. The available data for operating costs are very meager, but in comparing well-maintained, properly surfaced bridges, this item may be neglected without appreciable error. The term, low-cost bridges, does not include the bridge with a rough timber floor. The maintenance cost for this type of construction is so high and the service so unsatisfactory that it cannot properly be termed a low-cost bridge, even though the first cost may be low.

The amount of the annual renewal charge necessary to replace a structure at the end of its service life depends, of course, upon the estimate of the service life. More emphasis is generally placed on renewal charges than this item justifies. Experience indicates that all well-constructed bridges of steel, concrete, or creosoted timber may be expected to last more than 35 years. Renewal charges on any structure with a service life of that length become a small factor. Too great emphasis is placed on so-called permanent structures.

Many futile efforts have been made to secure permanence. Buildings are relatively one of man's most permanent achievements, yet no progressive community has any of the so-called permanent structures of a few decades ago. Many of our well-constructed bridges that are approximately only a decade old show marked evidence of deterioration, and frequently such structures have been abandoned because they were inadequate for increased traffic.

Obsolescence may be expected to eliminate many of the bridges that are being built at the present time long before these structures have reached the end of their economic service life. With the tremendous development of modern highway traffic it is difficult indeed to anticipate just what future needs may be, particularly in the secondary and county road systems. A charge for obsolescence sufficient to replace any structure at the end of from 35 to 40 years should be made. This charge should, of course, be increased for structures whose expected economic life is less.

MAINTENANCE AND INSURANCE

Maintenance costs vary widely with the different types of construction. Unfortunately, data on the maintenance of many of the materials and combinations of materials are very meager.

TABLE I. MAINTENANCE COSTS FOR PAINTING STEEL HIGHWAY BRIDGES IN OREGON FOR THE YEAR 1930

Bridge No.	Cost in Dollars per Ton: Labor	Material	Equipment	Total	Remarks
1	1.36	1.39	0.64	3.39	One coat
2	1.66	1.12	0.75	3.53	One coat
3	1.90	1.05	0.50	3.45	One coat
4	5.22	1.54	1.84	8.60	Two coats
5	3.95	0.91	0.41	5.27	One coat
6	5.35	1.80	2.25	9.40	Two coats plus cleaning
7	7.28	1.40	2.12	10.80	Two coats plus cleaning
8	2.05	0.50	1.05	3.60	One coat
9	5.50	1.50	1.65	8.65	One coat
10	5.50	0.60	0.62	6.72	One coat
11	1.45	0.55	0.32	2.32	One coat
12	1.65	0.42	0.15	2.22	One coat
13	5.58	2.25	2.00	9.80	One coat
14	5.70	3.50	1.75	10.95	One coat
15	18.70	2.75	3.25	24.70	Two coats plus cleaning
16	6.88	2.09	1.58	10.55	Two coats plus spotting

Perhaps the best data relate to structural steel. The principal item in the maintenance of steel is the cost of cleaning and painting. Other items such as replacing

COMBINATION BRIDGE WITH CREOSOTED TIMBER BENTS AND STEEL JOIST. SHEETED BENTS FOR 40-60-40-FT RIVER SPANS

Bridge Ready for Concrete Floor Forms, Which Are Supported on Lower Flanges of Floor Joist

rivets that work loose, tightening nuts, and replacing or adjusting expansion plates, are generally included under painting. The cost of painting varies very widely, depending upon the detail of the bridge and the exposure. In fact, average estimates should not be used without consideration of the exposure. The cost of painting is estimated by F. H. Frankland, M. Am. Soc. C.E., to be $1 per ton per year. In Table I is given information for various conditions in Oregon supplied by Mr. McCullough.

The maintenance cost of painting structural steel in the highway bridges of Georgia for the year 1931 is shown in Table II.

Maintenance on concrete structures includes repairing guard rails, patching over steel placed too near the surface, repairing expansion joints, and other minor items. The annual maintenance cost per year on this type of work has been estimated to be 0.5 per cent of the first

cost of the structure. With great care in working out details of design, selection of materials, and construction, this repair charge can be reduced, but such perfection in construction work is difficult to attain.

On creosoted timber structures the maintenance cost varies widely with the different types of construction. Estimates by J. F. Seiler, Service Engineer of the American Wood Preservers' Association, indicate the annual maintenance cost on creosoted timber structures to be 1.5 per cent of the first cost. This amount is based largely on information secured from railroad engineers.

Bridge No. 1, a Concrete Trestle; Cost, $14,300; Annual Charges, $930

Bridge No. 2, a Combination Wood, Steel, and Concrete Trestle; Cost, $8,800; Annual Charges, $846

COMPARATIVE TYPES OF CONSTRUCTION OF EQUAL LENGTH

TABLE II. MAINTENANCE COSTS FOR PAINTING STEEL HIGHWAY BRIDGES IN GEORGIA IN 1931

	Cost in Dollars per Ton per Year				
Bridge No.	Labor	Materials	Incidentals	Total	Remarks
1	0.72	0.48	0.14	1.34	Cleaned wire brushes 1 coat red lead 1 coat aluminum
2	1.04	0.46	0.18	1.68	Cleaned wire brushes 1 coat red lead 1 coat aluminum 2,640 ft extra pipe handrail
3	0.81	0.43	0.16	1.40	Cleaned wire brushes 1 coat red lead 1 coat aluminum Bottom partial
4	1.41	0.39	0.38	2.18	Cleaned sand blast 1 coat red lead 1 coat aluminum
5	0.63	0.74	0.68	2.05	Cleaned sand blast 1 coat red lead 1 coat aluminum Bottom partial
6	0.85	0.41	0.34	1.60	Cleaned sand blast 1 coat red lead 1 coat aluminum Bottom partial
7	2.06	0.72	0.64	3.42	Cleaned sand blast 1 coat red lead 1 coat aluminum Bottom partial
8	1.76	0.59	0.57	2.92	Cleaned sand blast 1 coat red lead 1 coat aluminum Bottom partial
9	1.13	0.39	0.29	1.81	Cleaned sand blast 1 coat red lead 1 coat aluminum Bottom partial
10	1.21	0.33	0.22	1.76	Cleaned wire brushes 1 coat red lead 1 coat aluminum Bottom partial

Mr. Seiler states that adequate information on the maintenance cost of highway bridges is lacking. Taking into account the cost of replacing material, which decays as a result of improper treatment, careless handling, cutting after treatment, and other factors of common occurrence, this estimate is probably low. The same charge is estimated by Mr. McCullough to be about 3 per cent, which seems to be fair.

Under insurance should be included only insurance against fire. Insurance against tornadoes, flood disasters, or earthquakes would be about the same for any type of construction, although it is claimed that in the event of a flood some timber material could be salvaged, whereas nothing would be saved if the structure were of concrete or steel.

Experience in the fire hazard of creosoted timber structures seems to vary widely in the different states. The state of Georgia, which has a large number of these structures in its highway system, up to the present time has had no loss due to fire, while the neighboring state of South Carolina reports the loss of several structures from this cause. One of the larger railroads in the Southeast reports no loss from fire, whereas another railroad company reports the loss of a number of structures. It is estimated by Mr. Seiler that one-fourth of 1 per cent per annum of the first cost represents the fire hazard. Insurance rates generally quoted are from 0.6 to 0.7 of 1 per cent. Assuming that the insurance companies include profits and commissions in their rates, it would seem that an estimate of from 0.4 to 0.5 of 1 per cent would be fair for this charge.

TWO TYPES OF CONSTRUCTION COMPARED

To illustrate the application of annual costs, a comparison will be made between a concrete trestle 238 ft in length, consisting of seven 34-ft deck girder spans with concrete rails, supported by two-column concrete bents, and a structure 240 ft in length consisting of a series of creosoted timber pile bents supporting steel beams carrying a concrete floor and concrete rail. Open-type end bents were used on both structures, and an item covering the cost of placing riprap to protect the fills has been added to both estimates. The unit prices used are based upon the current bid prices on work of this kind, which were received in Georgia during 1931. Interest rates are assumed at 5 per cent.

Bridge No. 1 was a concrete trestle, with a length of 238 ft and a roadway width of 24 ft. The first cost was $14,277.70, the cost per lin ft being $59.99. The annual charges will then be as follows:

Interest on investment ($14,277.70) at 5 per cent	$713.89
Maintenance and retirement on $14,277.70 at 1.5 per cent.	214.16
Total annual charges	$928.05

Bridge No. 2 was constructed of creosoted timber pile bents, steel joists, concrete floor, and rail. It is 240 ft in

length, with a roadway width of 24 ft. The first cost was $8,810.50, and the cost per linear foot, $36.71. The annual charges for this bridge will be:

Interest on investment ($8,810.50) at 5 per cent	$440.53
Maintenance and retirement on $8,810.50 at 4.1 per cent	361.23
Insurance (fire) on $8,810.50 at 0.5 per cent	44.05
Total annual charges	$845.81

The maintenance charge for Bridge No. 2 is perhaps a little high as this structure has a concrete floor and rail, and the steel joists are well protected by the concrete

CONCRETE BRIDGE WITH OPEN END BENTS
In This Economical Design Approach Fills Around End Bents Are Protected with Riprap

floor slab. The insurance charge is also high as the rate of 0.5 per cent applies to an all-timber bridge.

When viewed from the side, the concrete Bridge No. 1 presents a decidedly better appearance than Bridge No. 2. Viewed from the roadway, which is the point from which most people see them, they look about the same. The two types of construction represented are illustrated in the photographs of the bridges in question.

LOW-COST DESIGNS FOR CONCRETE CONSTRUCTION

An inspection of a large number of concrete bridges leaves the impression that little thought has been given to simplification of form work with a view to reducing costs. Concrete is a material that can readily be worked into elaborate designs, and the tendency has apparently been to increase the cost of the work through the addition of unnecessary details. Considerable saving can be effected, without impairing the appearance of the structure, by a consistent effort to simplify form work. This is particularly true on concrete guard rails.

The volume of concrete required can be reduced in girder and slab bridges by using continuous spans where foundation conditions warrant this type of construction. Continuous spans have the additional advantage of reducing the number of expansion joints that must be maintained. When full advantage is taken of continuity in a structure, the resulting stresses are reduced a surprising amount.

The use of open end bents instead of solid abutments nearly always shows a very material saving. To provide equal waterway this type of construction generally requires a somewhat longer bridge than would be needed if the solid abutments were used. If the slopes and end roll extending around the open end bents are well protected with riprap and grasses, experience indicates that this type of construction is just as safe against flood damage as a solid abutment, and there is little difference in appearance between the two types.

To illustrate the savings that can be made in this type of construction, comparative estimates will be given on two bridges. Bridge No. 1, which is 130 ft long, consists of five 26-ft concrete deck spans with a 24-ft roadway, two 3-column open end bents, and four 2-column intermediate bents. The cost of the structure at present unit prices for this type of work in Georgia would be $9,180.75. Bridge No. 2 is 78 ft long and consists of three 26-ft concrete deck spans with a 24-ft roadway, two abutments (counterforted type), and two 2-column intermediate bents. The cost of this structure in Georgia would be $12,061.25.

It will be noted that the length of the open-type end-bent bridge was increased 26 ft at each end to allow for the slopes extending through the end bents so as to provide equal waterway for both bridges. The estimate for the open-type end bent includes an item for protecting the slopes with riprap. The saving on this bridge by the use of open-type end bents as compared with abutments would be $2,880.50, or about 24 per cent.

Savings can also be effected by the use of rigid-frame structures under conditions where this type of design is justified. Some beautiful bridges of this kind have been constructed in Westchester County, New York. They

CANTILEVER GIRDERS IN CONCRETE
Main Span 75 Ft, Side Spans 58 Ft Long

are pleasing in appearance and show a marked saving when compared with the ordinary type of abutment and girder or slab bridges.

For those who are doubtful as to the efficiency of indeterminate structures, or when foundation conditions are such that the use of fully continuous girders is not advisable, cantilever-type girders can be used to advantage. The design gives a very pleasing appearance and is much more economical than simple girder spans of equal length. A bridge of this design is illustrated.

DESIGNS FOR STEEL CONSTRUCTION ECONOMICAL

Since the introduction of the deep-beam sections (30, 33, and 36 in. deep) now available, it has been possible to simplify greatly the details of steel construction, particularly in the shorter span bridges. Spans of from 60 to 100 ft can be designed by the use of available beam sections, which will show considerable savings when compared with the older type of low-truss construction. This type has the additional advantage of being easy to construct, and as the surfaces are flat they can be more readily cleaned and painted. Where a concrete floor slab is used, the beams are well protected from exposure and the cost of painting will be greatly reduced. By using concrete diaphragms and burning a few holes through the beams in the field the fabrication cost can be eliminated. No field riveting is required for this type of construction, and erection costs are surprisingly low. The concrete diaphragms between the beams should be placed before the slab is poured. This increases the stiffness of the beams and holds them in line as the load from the slab is added.

A comparison of the weights of structural steel and

castings of pony trusses with beam spans shows that the beam spans are somewhat lighter than the truss span. This is especially true of the cantilevered or continuous beam spans. The weight of the structural steel for the main spans of the steel-beam bridge of the cantilever type shown, consisting of two 60-ft side spans and a 90-ft main span with a 22-ft roadway, was 171,200 lb. This may be compared with the 199,000 lb of steel estimated for one 90-ft and two 60-ft pony truss spans with a 20-ft roadway.

The beam spans have the further advantage that they can be widened to permit of the addition of sidewalks if this becomes necessary, whereas the pony-truss spans cannot be widened. All steel in the beam spans is protected by the concrete floor slab and the surfaces are flat, so that painting costs will be much less.

The use of welded-steel floor plates is being promoted, and under certain conditions this type of construction has merit. However, maintenance and service experience with this kind of construction is very limited, and the type is economical only where saving in dead load is of considerable importance, as would be the case in long or movable spans.

CREOSOTED TIMBER CONSTRUCTION IN COMBINATION

The cost of creosoted timber can be reduced by using the sizes of timber that are readily obtainable. In the Southeast it is difficult to secure the larger sizes in a good quality of material. If the designs are carefully worked out, cutting treated timber in the field can be avoided. Even where great care is used in protecting and treating cuts, there is grave danger of decay at these points.

Timber bridge floors, if not protected by a wearing surface, are subject to severe deterioration from traffic and exposure to the weather. There are various kinds of wearing surface for timber floors, such as asphalt plank, rock asphalt, and bituminous mats. Maintenance costs on these wearing surfaces are, however, much higher than for concrete floors.

Numerous designs utilizing creosoted timber, steel, and concrete have been worked out. A design that is being extensively used consists of creosoted timber pile bents with creosoted timber caps supporting steel joists, and a concrete floor with guard rail either of concrete or timber. This design has many advantages both in cost and in ease of construction. The substructure consists simply of a series of pile bents. No excavation is required for the substructure, and where pile driving is done with an overhead rig, construction can go forward regardless of water conditions. No cuts are necessary in the creosoted material other than cutting off the piles. These cuts are well protected with galvanized iron caps and the wooden cap resting directly on the piles. The tops and ends of the wooden caps are generally covered with galvanized iron before the steel joists are placed.

Steel joists can be shipped without fabrication and can be erected easily. The concrete floor slab requires no centering extending to the ground, as the forms are supported by blocks between the bottom flanges of the I-beam joists. The maintenance costs are greatly reduced by having the steel joists well protected with a concrete slab. If a creosoted timber pile decays, the pile can be cut off below the ground line, a concrete pedestal built on top of the pile extending from several feet below the ground line to just above the ground line, and a post placed on this pedestal to replace the pile that has decayed. The concrete floor slab requires practically no maintenance with the exception of filling expansion joints with asphalt and keeping drain holes open.

The fire hazard on this type of construction is very low, the only danger being the possible loss of one or two piles due to brush fires. There is no danger of the fire's spreading from one part of the structure to another. At current contract prices in Georgia this type of construction costs from 38 to 40 per cent less than an all-concrete structure.

Many structures are being built with creosoted timber bents, creosoted timber joists, and concrete floor slabs. This type of construction has the advantage of a concrete slab for wearing surface with a creosoted timber substructure that requires comparatively little maintenance and no painting. The disadvantages, however, are that the span lengths must be greatly reduced if timber joists are used, and the details of placing the concrete floor slab on the timber joists must be carefully worked out to allow for shrinkage of the timber joists. At current prices of steel the creosoted timber joists cost very little less than the steel joists.

STEEL-BEAM BRIDGE OF CANTILEVER TYPE

Center Span, 90 Ft; Side Spans, 60 Ft; Approach Spans, 40 Ft

USE OF LOCAL MATERIALS

Any discussion of low-cost bridges would not be complete without mention of the use of local materials wherever those of durable quality are available. When properly used, the cedars and redwood trees found in sections along the Pacific Coast constitute durable bridge materials. In sections of the coastal region of the Southeast a good quality of heart cypress timber can be secured.

Black or red heart cypress timber is very durable when used in the regions where it grows, but when used in the upland country it is not nearly as durable. For short-span trestle construction in the coastal regions, cypress timber and cypress piles have been widely used. The economic life depends largely on the quality of timber secured, but where care is used a life of 20 years may reasonably be expected. The diameter of cypress piles should be specified in terms of heart diameter rather than outside diameter, as the sapwood is not durable and should not be considered for use.

ACKNOWLEDGMENTS

Papers on low-cost bridges were presented at the 1931 meeting of the Highway Research Board by E. M. Fleming, M. Am. Soc. C.E., of the Portland Cement Association, J. F. Seiler, of the American Wood Preservers' Association, and F. H. Frankland, M. Am. Soc. C.E., of the American Institute of Steel Construction. These papers were discussed by C. B. McCullough, G. G. Wickline, and H. H. Houk, Members, Am. Soc. C.E. Acknowledgment is hereby made for information and data taken from these papers and discussions.

Grouting Dam Foundations and Construction Joints

Successful Experience at Calderwood Dam Proves Instructive

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Modern practice in the design of dams has developed the need for a very thorough treatment of foundation and contraction joints. High dams in particular require the most complete foundation grouting possible. Low pressures, up to 100 lb per sq in., often are not sufficient. At Calderwood Dam, higher pressures, up to a maximum of 600 lb, were successful in providing a complete seal against the water and in solidifying the supporting rock. In view of the study and care given to this outstanding job, Mr. Hays' description of the procedure followed and the results obtained, together with his recommendations for such work under similar conditions, should prove of great value.

Calderwood Dam on the Little Tennessee River in southeastern Tennessee, approximately eight miles from the North Carolina line, is a part of the hydro-electric system supplying power for the use of the Aluminum Company of America at Alcoa, Tenn., in the manufacture of aluminum. This dam, 232 ft in maximum height, is of the variable-radius arch type. The radius to the axis of the crest is 325 ft, and the crest length is 740 ft. The discharge of surplus water over the top of the dam is controlled by 24 Stoney-type flood gates, each 20 ft high by 24 ft long. The water has a free fall into the cushion pool formed by an ogee-shaped gravity-type dam 40 ft high, about 400 ft downstream.

The maximum elevation of the water surface above the dam is 965 ft. The gate sills are at elevation 945. Between this level and elevation 900 the dam is 25 ft thick and both its faces are vertical. Between elevations 900 and 820, both faces slope to fit the curves of the arch rings. Between elevations 820 and the river bed, the downstream face is vertical. The general layout is shown in Fig. 1.

In the vicinity of the dam the predominating rock is arkose, a stratified, metamorphosed sandstone, occurring in layers from a few inches to 10 ft or more thick. It varies considerably in texture, from fine to coarse, the latter approaching a conglomerate. Weathering has affected the rock in different ways, the fine grained being generally the most resistant. Often a weathered layer was found which extended a considerable distance underneath a series of solid layers. Slate was also found in beds and lenses and very often in thin seams, or partings, between the layers of arkose. Although weathering seemed to have been rather rapid on the exposed faces of the slate beds, they were solid and sound when protected. Folding and faulting, characteristic of the region, were found at the dam site. The geological features with reference to the dam are shown in Fig. 1.

At the right abutment bedrock was covered with an overburden 20 to 40 ft thick, but when exposed it was relatively smooth and consisted almost entirely of a single layer of ledge rock. The dip varied from 35 to 45 deg towards the river, while the strike was nearly parallel with it. A view of this abutment when the foundation for the lower part of Block 18 was about completed is shown in a photograph.

In the river bed a sharp fold was uncovered, and further towards the left bank there were two slips, or minor faults, both of which were relatively tight. The left abutment consisted of a very steep cliff exposing the edges of the rock layers. After some preliminary excavation, a fault was uncovered and diamond drill cores were taken to determine its extent and condition. It was found that the faulting plane was vertical and parallel to the river and intersected the springing line of the arch on its axis at an angle of 13 deg from the tangent to the curve at the crest. The cores indicated the presence of weathered rock, from 3 to 20 ft thick, in the vicinity of the fault. Several cracks, nearly vertical and parallel to the river, were also discovered in the rock beyond the fault. Later it was found that these were quite open and would readily drain rainwater from the upper surface of the cliff.

After a thorough study of the situation, a tunnel was driven at elevation 820, a short distance downstream from the end of the dam, to intersect the fault zone. All weathered material included in this zone and lying between the intersections of the up- and downstream tangents from the end of the arch was removed and later replaced with concrete. Below elevation 820, where arch action is limited, the shorter radii of the arch brought the resultants more nearly parallel to the fault and into solid material. The cracks in the cliff beyond the fault were investigated by extending the tunnel 35 ft into the abutting ledge. Within this distance four well-defined cracks, or vertical joints, were found.

FOUNDATION GROUTING REQUIREMENTS

General requirements for grouting the foundations called for a seal, or curtain, along the upstream face of the dam to prevent leakage and uplift pressure. Although a small amount of leakage in itself is not always serious, its ultimate effect cannot be foretold. The goal is a grout curtain that will be 100 per cent water-tight. Uplift is a serious matter in the case of gravity dams but only of minor importance in thin arch dams. Thorough drainage must be had under gravity sections.

At Calderwood, a tight grout curtain was required from end to end. With heavy gravity abutments at the ends, thorough foundation drainage was necessary to prevent uplift. Because of the geological structure of the two abutments and the faulted condition of the left abutment, grouting of the highest efficiency was essential. Since ordinary low-pressure grouting was considered insufficient, the high-pressure method was adopted at the abutments.

On the right bank, water pressure, if once established in the lower seams, would tend to overturn the abutment block or possibly cause it to slip downhill. On the left bank thorough grouting was necessary to prevent numerous springs of reservoir water from coming out of the

side of the cliff for a distance of several hundred feet downstream from the dam. Water pressure in open joints or cracks would also tend to overturn the abutment at this end of the arch.

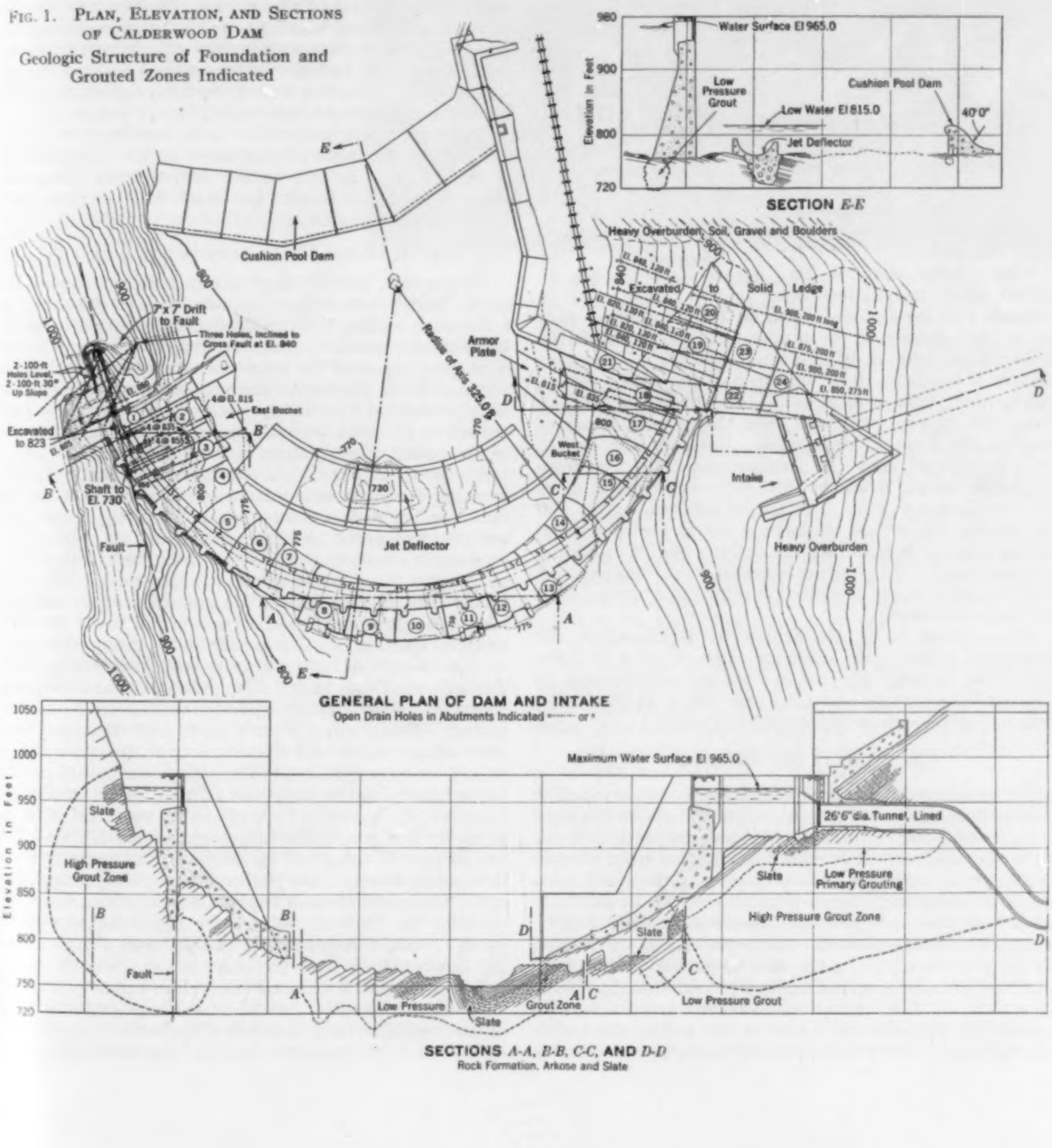
Since the high-pressure grouting required a much greater depth of hole than could be secured with ordinary jackhammers, diamond drills were used not only to get the necessary information regarding the geological structure but also to provide grout holes. The specifications required the grouting of a set of primary holes 30 ft deep and 10 ft from center to center. After this work was completed, a set of secondary holes was drilled midway between those of the first set, thus enabling a check on the efficiency of the holes first grouted. The secondary set of holes was then grouted. If an appreciable quantity of cement was required to fill them to refusal, additional holes were then drilled between the secondary holes and grouted until the rock was made tight.

Whenever possible, a hole was grouted as soon as it was drilled and before drilling was begun on the next adjoining hole. Very often construction operations would not allow such procedure, and several holes would be drilled before the first was grouted. Primary grouting was done before concreting; secondary grouting often had to be done after the first lift of concrete was placed in order not to delay the progress of construction.

TWO METHODS OF DRILLING

Heavy jackhammers or "sinkers," using $1^1/_4$-in. steel in lengths up to 30 ft, were used for drilling. The starter drills had a diameter of 3 in. across the face of the bit. The drill sizes were successively reduced until the holes had a diameter of $1^3/_8$ in. at the bottom. It is very inconvenient to handle steel much longer than 30 ft. Two men operating one hammer could drill a 30-ft hole in three hours. However, because of interruptions to the work and the time required in moving from one hole to the next, the average progress was about two holes per

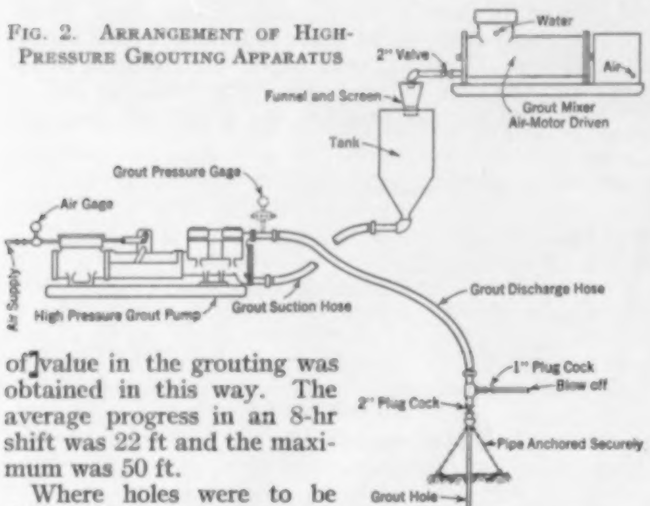
Fig. 1. Plan, Elevation, and Sections of Calderwood Dam
Geologic Structure of Foundation and Grouted Zones Indicated



10-hr shift. The cost of this work averaged about 50 cents per ft, which included handling of the steel to and from the shop, sharpening of the bits, and overhead. Drilling was usually started near the upstream left-hand corner of a block, whence it progressed to the right.

Diamond drilling was used for holes more than 30 ft deep, for the high-pressure grouting, and for all the deep drainage holes under the abutments. Holes drilled into the abutments ranged from 50 to 240 ft in depth. All the cores, which had a diameter of $1^9/_{16}$ in., were preserved, and notes regarding the stratification of the ledge and the occurrence of seams or cracks were taken during the drilling operations. Considerable information of value in the grouting was obtained in this way. The average progress in an 8-hr shift was 22 ft and the maximum was 50 ft.

FIG. 2. ARRANGEMENT OF HIGH-PRESSURE GROUTING APPARATUS



Where holes were to be drilled after several feet of concrete had been placed, 2-in. or 3-in. iron pipes were set in the concrete at the proper location and with the correct slope, and the drilling was done later. Numerous shallow holes, 8 to 10 in. in depth, were drilled with a jackhammer, using a large bit. These holes, which had 2-in. pipe nipples cemented into them, were used for starting the diamond-drill holes. Extreme care had to be exercised to keep the jackhammer holes free from fragments broken from the steel bits, which might damage the diamond drill. The use of the 2-in. nipple had the double advantage of keeping metal particles from falling into the hole during the drilling and of providing a connection for the grouting operations that was superior to a 1-in. pipe nipple cemented in after the diamond drilling was completed.

Where grout holes are drilled by jackhammer, the seams and joints in the ledge are often plugged with the dust from drilling, whereas a diamond drill washes all debris to the surface and thus provides a much cleaner hole and hence one better suited to grouting.

GROUTING AT LOW PRESSURES

For grouting the primary holes low-pressure equipment was used, consisting of a grout mixer and placer having a cylinder of 6-cu ft capacity. Air pressure at 100 lb per sq in. was applied. Two-inch pipe nipples from 18 to 20 in. long were anchored 8 to 10 in. deep in the grout holes either by cementing, when time allowed, or by caulking with lead wool. Where the holes encountered flowing water, lead wool was used. A plug cock was screwed on the end of the nipple; a tee was connected to this cock; and the side outlet of the tee was provided with a blow-off valve. A 2-in. high-pressure rubber grout hose connected the tee with the valve at the end of the grout-mixing tank. With this set-up, there was no trouble due to plugging of the hose or the pipe connections, since the blow-off valve was frequently cracked open during grouting. This valve was also used to release air from the hose and pipes when grouting was started.

The usual procedure was to fill the tank half full of water while the outlet valve was kept closed. This quantity of water, that is, 3 cu ft, was used in practically all the grout mixtures. If the condition of the seams or joints crossed by a hole was unknown, one bag of cement was mixed for the first trial batch. For a "slow hole" this mixture was repeated. If the batch was taken rapidly, a thicker mixture, that is, two bags of cement with the same quantity of water, was tried. Batches were thickened as required by increasing the amount of cement added, up to four bags in 3 cu ft of water. In a few instances thicker grout was used. But no batches contained more than five bags of cement. Grout of thicker consistency than this was made by reducing the quantity of water. No sand was used.

Where open underground seams permitted flow from one hole to another, valves were screwed on the nipples in the flowing holes in order to retain pressure during the grouting. Immediately after grouting a given hole, all the other holes that had shown evidence of leakage during the grouting operation were tested for tightness, but in almost every instance they refused more grout.

The foundation under the arch, Blocks 4 to 17 inclusive, was grouted at low pressure only. The quantity of cement used in this section varied from 6 bags for Block 4, to 413 for Block 14. In all, 2,474 bags were required under the arch.

MODIFICATIONS FOR HIGH-PRESSURE GROUTING

To prevent undue blowing out and wasting of the grout, high-pressure grouting was always preceded by a thorough sealing of the surface seams and cracks by the low-pressure method. Similar procedure was followed in re-grouting until the ledge was considered thoroughly sealed. Both abutment foundations were grouted at high pressure. The high-pressure grout curtain was extended to the zone beneath the upper horizontal section of the main tunnel leading to the power house.

As shown in Fig. 2, the equipment for high-pressure grouting consisted of a mixer, a No. 5 screen, a storage tank, and a high-pressure pump. For the mixer, the low-pressure grout machine was used. It was set at such an elevation as would allow the mixed grout to flow by gravity through the screen into the tank. The tank was a vertical cylinder with a conical bottom and was large enough to hold more than one full batch from the mixer. The 2-in. suction hose from the pump, which was set low enough to have a gravity feed, was connected to the bottom of this tank. The pump pistons had special rubber packing, and the cylinder walls were readily replaced. Practically the only parts that wore out were the balata valves and the cast-iron valve seats, all of which were inexpensive. The valve seats were usually turned down in the shop and re-used twice. As in the low-pressure layout, a blow-off valve was located in the grout line as near to the hole as possible. By observing the surface of the grout in the tank, the operator could determine whether the pump was working properly or not. Clogged valves in the pump were often cleared by opening the blow-off valve. By the same means, the operator could diagnose the trouble when the grout was not flowing freely from the tank.

It was essential that all the valves operate properly. A steady lowering of the surface of the grout in the tank, or a smooth flow from the blow-off valve, indicated proper operation of the pump. A jerky or pulsating flow indi-

cated that one or more of the pump valves was stuck. When this occurred, the pump was opened immediately and all the valves were cleaned, or replaced if necessary. After the completion of each grouting operation, clear water was passed through the pump until the discharge showed no color. Then the pump covers were removed and the valves and valve chambers thoroughly cleaned.

With air at a pressure of 100 lb per sq in. for driving the pump, a maximum pressure of 600 lb per sq in. was applied to the grout. A high-pressure gage on the grout line indicated a pressure of approximately six times that in the air line. This gage was later removed because it required too frequent cleaning, and the low-pressure or air gage gave the necessary information.

To fill a hole to refusal, the pump was operated until it stalled. Only twice during the high-pressure grouting did the air gage indicate a pressure of more than 15 or 20 lb, up to the last few batches of grout. No plugging of the hose or pipe lines occurred. With this equipment, grout was forced through as much as 200 ft of pipe to reach inaccessible holes. The only disadvantage arising from the use of such long pipes is the loss of grout when they are washed. Care was exercised in fitting pipe connections and properly anchoring them at all bends. No breaks occurred.

A mixture of four bags of cement in 3 cu ft of water, used for all the high-pressure grouting, was about as thick as could be handled by the pump. No advantage was found in using thinner mixtures.

On one hole a comparison was made to determine the relative efficiency of the two systems. This hole refused more grout after it had taken 26 bags of cement under low pressure. The high-pressure apparatus was then quickly connected, and 400 additional bags of cement were forced into the hole before final refusal occurred. There were no leaks.

On the right abutment, where there are no faults, grout made from 508 bags of cement was forced into 1,625 lin ft of holes under low pressure, and 1,255 bags of cement were used in grout placed under high pressure in 1,472 lin ft of holes. The low-pressure grouting covered an area of 10,000 sq ft and the high-pressure grouting, 27,000 sq ft.

In the left abutment, which was seriously faulted, 1,317 lin ft of holes required 719 bags of low-pressure grout, and 3,935 lin ft of holes required 3,429 bags of high-pressure grout. In this area, 8,000 sq ft were grouted under low pressure, but the broken condition of the rock required that 27,000 sq ft of area be grouted under high pressure.

The only blow-out during the high-pressure grouting was from one of the holes along the face of Block 22, extending into, or through, a slate seam. No damage was done, and a second hole, drilled nearby, was grouted to refusal.

Grouting on the right abutment consisted in establishing a curtain along the upstream face of Blocks 18, 22, and 24 and under the main tunnel to a depth of 140 ft, which brought the bottom of the drill holes level with the river bed. On the left abutment the curtain extended horizontally into the side of the mountain, from the bottom of the shaft at elevation 770 upward in an inclined or warped plane to the top of the dam at Block 1.

On the ledge below the right abutment, 30-ft vertical drain holes were drilled on 30-ft centers. None of these has leaked a drop since the reservoir was filled. Nine holes for drainage with a slight inclination above the horizontal were drilled under this abutment. The shortest was 120 ft and the longest 275 ft long. About 95 per cent of the present leakage from this abutment comes from two of these inclined holes. One of them had a fair-sized flow even before the reservoir was filled. A little later, the water level was lowered from elevation 965 to elevation 940, and the flow decreased to the original amount. This indicated that the water was probably percolating over the tunnel lining, where no grouting of the rock seams was done.

Right Abutment of Calderwood Dam
Overburden Removed and Ledge Rock Drilled for Grouting

In addition to the holes previously mentioned, five shorter holes were drilled in this abutment. They were intended to drain that part of the foundation covered by a relatively thin layer of concrete, but only a slight dripping from them has been observed. The total leakage from the right abutment is 12.3 gpm.

On the left abutment, seven diamond-drill holes were drilled from the small tunnel, which had been filled only partly with concrete. These holes, drilled at various angles and depths and penetrating beyond the concrete filling in the fault up to about elevation 860, are to collect any water that may leak through the grout curtain or around it.

Twelve holes were drilled in three rows of four each, from 20 to 25 ft on centers, each with a slight upward inclination from the horizontal, through the concrete face and the adjoining rock and a short distance into the concrete that filled the fault excavation. A few of these holes drip slightly, but there is no appreciable flow.

On the left bank the combined leakage from the drain holes downstream from the spray wall, including those in the tunnel, amounts to 10.5 gpm. Not a drop of water leaks from the rock or foundation at any point other than through these drain holes.

An outstanding feature was the excellent performance of the pump in the high-pressure grouting. If this job

were to be done again, a low-pressure pump and the same general arrangement of equipment would be used for preliminary and low-pressure grouting. For high-pressure grouting, pumps are now available for pressures up to 1,500 lb per sq in.

On the right bank the grout curtain should have extended over, and to the right of, the main tunnel. Upstream from Blocks 17 and 18 the grout curtain was vertical. It would have been more efficient if the holes had been drilled normal to the rock ledges under these blocks. Similarly, greater efficiency would have been obtained if all the holes for the low-pressure grout curtain along the upstream face of the dam had been inclined at an angle between 30 and 40 deg from the vertical and pointed upstream, away from the face of the dam. This would have tended to direct the resultant of the water pressure acting on the grout curtain downward, rather than horizontally, and also to reduce the downstream deflection of the arch near the base.

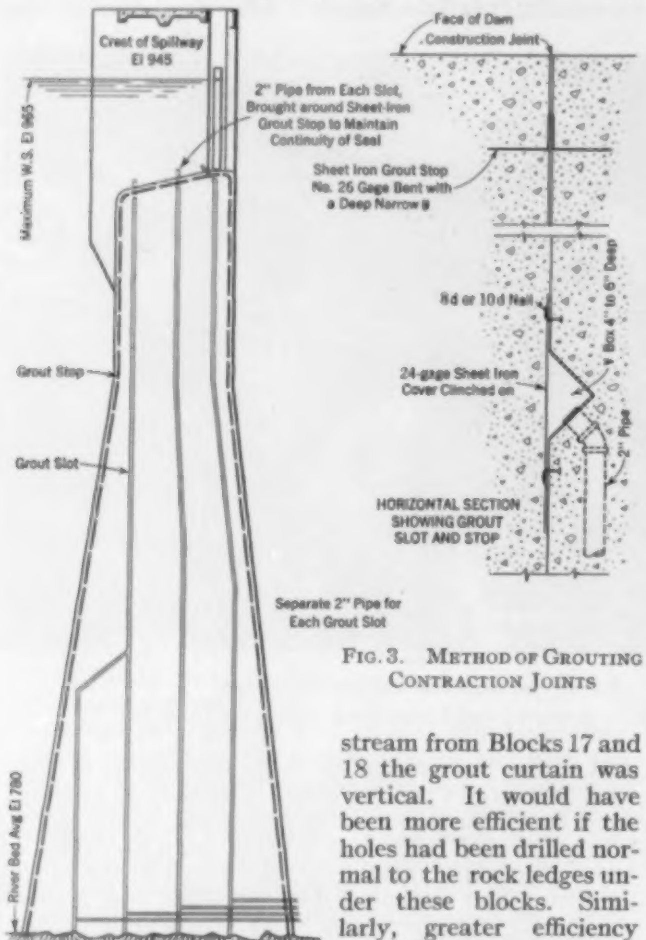


FIG. 3. METHOD OF GROUTING CONTRACTION JOINTS

Grouting can be utilized to good advantage in compacting a ledge which, while apparently sound, contains many seams and minute cracks. Sometimes the entire foundation area of a high gravity dam should be grouted so that the structure will withstand high pressures without serious deformation.

SEALING CONSTRUCTION JOINTS

Grouting of the contraction joints in the dam was required to counteract the shrinkage of the concrete in the blocks of the arch ring and to make the structure act as a monolith when loaded. Of the several methods tried, the one shown in Fig. 3 was finally adopted. It consists essentially of a series of vertical slots extending from the bottom to the top of the joint, each with a single outlet at the bottom, extending to the downstream face, and also with one at the top, projecting above the crest.

Slots were formed in the first block placed. Before concreting the adjacent block, sheet-iron covers were placed over the existing slots and held in place by nails anchored in the first block (Fig. 3). These slots were spaced 12 to 15 ft apart up to elevation 900, and 8 ft apart above that elevation. Of course the concrete in Calderwood Dam was not and could not be poured; it was too dry.

In order to prevent the slots from becoming plugged when concrete was being placed adjacent to them, separate pipes were required at the bottom of the joints for blowing compressed air through each individual slot. Immediately prior to grouting, all these bottom pipes in one joint were interconnected. At the top of the dam three pipes connected to these slots extended a few inches vertically above the crest.

From the grout machine at the top, the hose was connected to one of the three vertical pipes leading from the slots, and valves were connected to the other two. These valves were left open to release air, and the grouting was done as rapidly as possible. Four bags of cement in 3 cu ft of water, the only mixture used, provided grout about as thick as could be conveniently handled. The grout would flow down one slot, circulate through the interconnecting pipes at the bottom, and rise in all the slots at the same time. The valves at the top of the dam were closed as soon as thick grout appeared in them. Grouting was continued to refusal at a pressure of 100 lb per sq in. Since this pressure was measured at the top of the dam, it is evident that the hydrostatic pressure at the bottom was considerably greater.

Two machines worked simultaneously in grouting the vertical construction joints, beginning at the ends of the dam and progressing towards the center. Filling each joint required from three to five hours and from 75 to 135 bags of cement. As near as could be calculated, from 16 to 25 bags were forced into the joint itself and the remainder was used in the slots and pipes. This amount would allow for a joint opening averaging $^1/_{16}$ in. wide.

Only two leaks at contraction joints appeared when the reservoir was filled, but numerous wet spots were observed. One leak was grouted from the downstream face. The other became negligible within a short time. At present there are very few leaks through the dam and most of these are where a day's work in concreting ended.

In future dams smaller slots might be used, in which case more care would be necessary to prevent them from becoming plugged. Closer spacing could also be adopted to remove any doubt as to the proper distribution of the grout throughout the joint. Since speed is essential, two machines could be used advantageously in grouting each joint. A pump installed at the bottom of the dam might also be used to advantage.

In the case of an arch dam, it is possible by simultaneous pressure grouting of each of the vertical contraction joints between the horizontal arch rings, to deflect the dam upstream a sufficient amount to offset the cantilever and twisting stresses occurring normally in the structure when hydrostatically loaded. When thus loaded, the dam would return to its original and designed position. Besides eliminating such cantilever and twisting stresses, this method would also remove a part of the horizontal bending moment and, when loaded, the dam would be a true circular arch. Temperature is one of the variable elements to be considered in making computations for the desired upstream deflections.

Calderwood Dam was designed and built under the direction of James W. Rickey, Chief Hydraulic Engineer, and his assistant, J. P. Growden, both members Am. Soc. C.E.

Permeability of Concrete Under High Water Pressure

By Cornelius C. Vermeule
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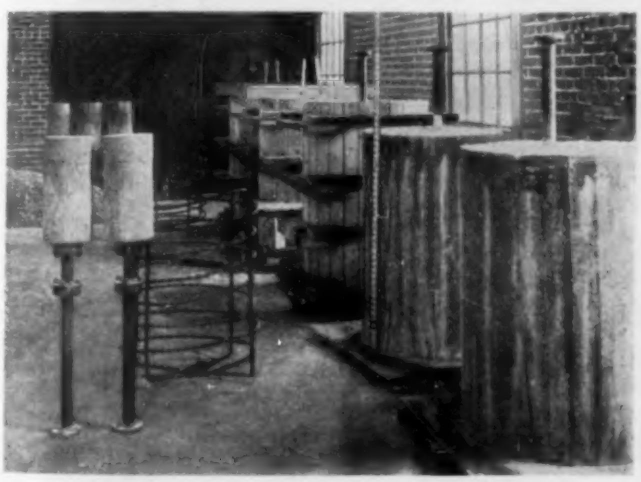
In 1919 tests were made to determine the water-tightness of concrete, for lining the pressure tunnel penstock of a proposed hydro-electric plant, construction of which is still pending. Mr. Vermeule made these tests of various mixes of concrete under pressure up to 200 lb per sq in. The records of his tests are here published for the first time in order to increase present knowledge on the subject of the permeability of concrete under water pressures exceeding 70 lb per sq in. They indicate that concrete may be made impervious when mixed with cement and mortar, both of which are in excess of the voids by about 20 per cent. The addition of hydrated lime appeared to add water-tightness, and an interval of waiting of two weeks after the first application of pressure also added to the imperviousness of the concrete.

In the design of a hydro-electric plant operating under a 500-ft head, for the Cienfuegos, Palmira and Cruces Electric Railway and Power Company of Cuba, in 1919, it was found that both topographic and labor conditions favored the construction of a penstock tunnel 4,820 ft in length. The rock is partly basaltic and partly limestone. In the latter there are short sections that cannot be entirely relied upon to support the internal pressure. Here a concrete lining must be heavily reinforced with steel bars. A part of the penstock is to operate under a pressure of fully 200 lb per sq in. Economy and durability will be secured by a concrete lining, although any water finding its way through the lining will, in some parts of the limestone, have a free outlet through the natural rock. The internal diameter of the finished penstock tunnel is to be 8 ft 6 in. To avoid a sharp rise of pressure, due to a sudden closing of the wheel gates under fluctuating loads, it was decided to introduce relief valves near the power plant. By means of these the rise would be limited to about 50 lb above the ordinary working pressure. It was feared that the concrete might disintegrate if there should be a continuous seepage of considerable amounts of water through the lining.



Construction of Concrete Test Drums
Interior Chambers, Reinforcement, and Completed Drums

In view of all these conditions it became necessary to have more complete data concerning the permeability of concrete under a pressure of 200 lb than were available. A series of tests was therefore made by applying internal hydraulic pressure to drums or cylinders of concrete composed of different proportions of aggregates. A form of drum was designed that could be depended upon to withstand a pressure of 200 lb per sq in. without fracture, and much care was taken in the design and manufacture of these drums to prevent leakage through the connections. This precaution was taken in order that the water actually absorbed by, or permeating, the concrete might be accurately determined.

Design of the Test Drums

The ten drums were made in the form of cylinders, 30 in. in diameter by about 42 in. long, with an interior hollow chamber 4 in. in diameter by 9 in. long. They were made of concrete of varying proportions of aggregate, as shown in the tabulation of data for the tests, and all were reinforced alike with $^1/_2$-in. cold twisted square rods made up in the form of a spiral with longitudinal rods enclosing the spiral in two loops.

Water pressure was applied through a $1^1/_2$-in. wrought-iron pipe built into one end of the cylinder and terminating in the interior chamber. In order that the main drum might be cast as a monolith and that no interior form of wood or metal might intervene between the water applied and the concrete, an interior hollow concrete cylinder was first cast on the end of the feed pipe. Its walls were 2 in. thick, and it was bonded to the wrought-iron pipe. This pipe, which conveyed the water to the interior of the chamber, was fitted with three flanges to act as baffles and was boiled for half an hour in water containing washing soda to remove all grease from the metal. The outside of the pipe was scored with a coarse file to ensure good contact with the concrete and to prevent leakage along the pipe when it was under high pressure.

Concrete caps to close the ends of these interior chambers were cast separately and were sealed in place with cement mortar as soon as the concrete had set sufficiently to permit of safe removal of the interior cylindrical form. The concrete for each chamber and cap was made of the same mixture as that used in the corresponding monolithic drum. The forms that were used for the small interior chamber are shown in one of the accompanying illustrations.

Fineness of Cement

About three weeks before the tests were made, the portland cement to be used was received from the mill. Four sets of standard-sized pats of neat cement which were made, showed the cement to be uniform for time of initial and final set and for constancy of volume. The cement was of such fineness that 80 per cent passed a

200-mesh sieve, and only 3.2 per cent was retained on a 100-mesh sieve.

The sand was well graded and sharp, containing by weight 1.6 per cent of loam. It weighed 96.0 lb per cu ft and contained 42 per cent of voids. A mechanical analysis of it is given in Table I.

TABLE I. MECHANICAL ANALYSIS OF SAND IN TEST CYLINDERS

Sieve Number	Separation in Mm	Per Cent Retained on Sieve	Per Cent Finer Than
...	....	0.1	...
200	0.10	0.2	0.1
130	0.13	0.3	0.3
100	0.17	2.8	0.6
70	0.24	8.5	3.4
50	0.36	26.1	11.9
36	0.53	19.9	38.0
24	0.83	14.8	57.9
16	1.30	14.1	72.7
10	2.10	13.2	86.8

Effective size (10 per cent finer than) = 0.34
Uniformity coefficient = 2.44

The crushed stone was a uniformly graded, clean, granitic rock, from $1/8$ to $3/4$ in. in size, with the crusher dust screened out. Its weight was 95.6 lb per cu ft, and it contained 44 per cent of voids.

Both sand and stone were housed for two weeks in the room where the drums were made and tested. The temperature of this room varied from 50 to 70 F, so that the materials were kept reasonably dry and uniformly warm. The water for mixing mortar and concrete was taken from an artesian well and heated to a temperature varying from 62 to 70 F.

Each drum was built on end upon a square platform of dressed boards. The cage of spiral reinforcement was suspended within the form to provide for from $2\frac{1}{2}$ to 3 in. of concrete outside of the metal on all surfaces of the drum. It was made of $1/2$-in. cold twisted square bars, formed with a pitch of 5 in. about a circular wooden form 20 in. in diameter. The spiral was then enclosed in two longitudinal loops and fastened to them with telephone wire.

The interior concrete chamber, with its pipe connection, was so placed within the cage as to provide for 11 in. of concrete on all sides outside of the 2-in. walls of the chamber.

A clamp placed across the outside of the form at the top held the reinforcement cage, the interior chamber, and the supply pipe in position. The reinforcement cage was also wired to the outside form, which held it at a fixed distance from the form.

Concrete for each drum was mixed by hand on the concrete floor of the room, adjacent to the forms. It was then put into pails, poured into the forms, spaded, and tamped thoroughly into place. For each drum containing 17.1 cu ft of concrete, 115 lb of water was used in mixing, and in all drums water appeared at the surface when the concrete was tamped in the forms. The sizes of the drums and proportions of the mixture are given in Table II.

Immediately after the drums were cast the interior chambers contained about $1/4$ in. of clear water over the bottom. This disappeared in a few hours leaving the chamber dry except in one case. Drum No. 2 contained $1/2$ in. of clear water, which did not entirely dry out for four days. After casting, all the drums were left on end for three weeks to set. They were then turned on their sides and lined up on skids with their pressure pipes in position for connecting with the testing apparatus.

TESTING APPARATUS

A device for applying the water pressures to the concrete of the drums was set up as shown in one of the accompanying illustrations. To form an air chamber, a piece of extra heavy wrought-iron pipe, 6 in. in diameter and 6 ft long, was set up vertically, both ends being fitted with extra heavy cast-iron flanges $1\frac{1}{2}$ in. thick. The bottom flange was connected with a horizontal $1\frac{1}{2}$-in. water line. One end of this went to the pressure pipe built into the drums and the other, containing a globe valve and a check valve, was connected with a hand-operated force pump.

The top flange of the vertical pipe was fitted with a standard pressure-testing gage, reading to 200 lb per

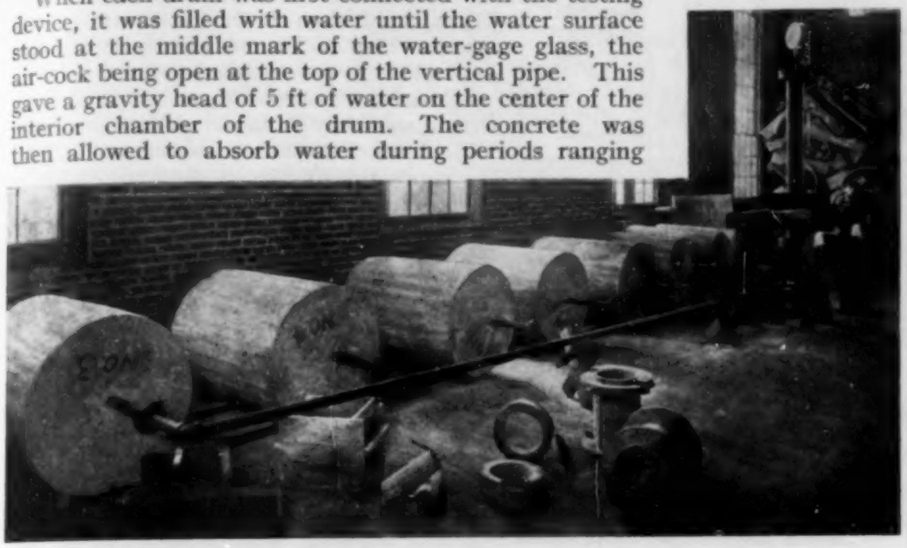
TABLE II. WATER REQUIRED FOR SATURATION AND TO MAINTAIN GIVEN PRESSURES IN DRUMS, FOR BOTH ABSORPTION AND LEAKAGE

				Saturation		100 Lb Pressure			150 Lb Pressure			200 Lb Pressure			
							Water Used			Water Used			Water Used		
Drum No.	Dimensions in Inches	Composition	Age When Tested	Time Hr-Min	Water Used in Lb	Time Hr-Min	Lb	Lb per Hr	Time Hr-Min	Lb	Lb per Hr	Time Hr-Min	Lb	Lb per Hr	Remarks (March and April 1919)
1	30 × $41\frac{1}{2}$	1:$1\frac{1}{2}$:3	19 days	24-0	14.0	1-15	0.75	0.60	0-30	0.31	0.62	1-30	0.56	0.37	200 lb for 30 min produced moist spots. No leakage
2	30 × $41\frac{1}{2}$	1:$1\frac{1}{2}$:3	24 days	46-30	$7\frac{1}{2}$	18-50	0.13	0.007	2-30	0.25	0.10	1-25	0.31	0.22	No moist spots or leakage
3	30 × $42\frac{1}{2}$	1:2:4	27 days	20-0	7.0	2-0	2.25	1.12	2-0	2.12	1.06	3-10	4.25	1.35	100 lb for 10 min produced moist spot
4	30 × $42\frac{3}{4}$	1:2:4	29 days	18-0	$7\frac{1}{4}$	2-0	1.50	0.75	3-0	3.75	1.26	4-0	4.75	1.19	150 lb for 30 min produced moist spot
4*	30 × $42\frac{3}{4}$	1:2:4	45 days	42-30	$1/4$	1-30	0.97	0.65	1-30	0.97	0.65	2-0	1.30	0.65	100 lb for $1/2$ hr produced moist spot
5	30 × 43	1:2:4 + 10% lime	31 days	45-20	$4\frac{1}{2}$	1-0	0	0	0-50	0	0	24-0	5.91	0.25	200 lb for 1 hour produced moist spot
5*	30 × 43	1:2:4 + 10% lime	47 days	20-0	$3/8$	0-30	0	0	0-30	0	0	24-0	4.25	0.18	No moist spots or leaks
6	30 × $41\frac{1}{2}$	1:2:4 + 10% lime	28 days	18-30	$10\frac{3}{4}$	1-0	0	0	1-0	0	0	25-10	8.63	0.34	200 lb for 1 hr 20 min produced moist spot. No leakage
7	30 × $42\frac{3}{4}$	1:$2\frac{1}{2}$:5	30 days	18-45	$6\frac{1}{4}$	2-0	1.84	0.92	20-30	18.81	0.92	3-0	5.50	1.83	100 lb for 1 hr produced moist spot
8	30 × 41	1:$2\frac{1}{2}$:5	32 days	43-30	10.0	3-0	0.31	0.10	19-20	7.25	0.38	4-30	5.75	1.33	100 lb for 2 hr produced moist spot
9	30 × 43	1:$2\frac{1}{2}$:5 + 10% lime	35 days	18-0	1.0	2-0	2.25	1.12	19-10	22.25	1.16	5-0	7.25	1.45	50 lb for $1/2$ hr produced moist spot
						75 Lb of Pressure			100 Lb of Pressure			125 Lb of Pressure			
10	30 × $43\frac{1}{2}$	1:$2\frac{1}{2}$:5 + 10% lime	37 days	18-0	$5\frac{1}{4}$	21-30	12.0	0.56	3-0	2.70	0.90	1-0	0.90	0.90	50 lb for 3 hr produced moist spots
10*	30 × $43\frac{1}{2}$	1:$2\frac{1}{2}$:5 + 10% lime	43 days	....	....	19-50	4.75	0.24	3-0	1.50	0.50	2-30	1.75	0.70	100 lb for 30 min then left for night, when moist spots appeared

* Indicates a second test for the numbers of drums given. Pressure of 50 lb not tabulated as it does not add sufficient information.

sq in. The $^1/_2$-in. air line leading to an air pump was fitted with a check and globe valve. On the side of the air chamber about 2 ft below the top, a glass water gage was attached. By means of this the level of water employed in saturation, or pumped under pressure into the concrete drums, could be determined. The hand force pump had a long stroke so that the pressure could easily be maintained by making an occasional slow, downward motion.

When each drum was first connected with the testing device, it was filled with water until the water surface stood at the middle mark of the water-gage glass, the air-cock being open at the top of the vertical pipe. This gave a gravity head of 5 ft of water on the center of the interior chamber of the drum. The concrete was then allowed to absorb water during periods ranging



Test Drums and Apparatus—Forms for Interior Chamber in Foreground

from 18 to $46^1/_2$ hr, before pressure was applied. The amount of water thus taken up by each drum was determined by weighing the amount that must be pumped in order to maintain the water at a constant level in the gage glass. A period of from 18 to 20 hr was found by test to be sufficient to saturate the concrete drums, after which there was no further measurable quantity of water taken up by the concrete until pressure was applied. The amount of water thus absorbed is shown in the column headed "Saturation" in Table II.

Pressures varying from 50 to 200 lb were applied to nine of the drums. A pressure of 50 lb produced only from 0 to 0.35 lb of absorption per hour per drum, but the higher pressures showed absorption and leakage for given periods of time, as indicated in Table II.

In beginning a test after a period of saturation, or in changing from one pressure to another, the water was drawn down to a level $^1/_4$ in. above the bottom of the water-gage glass. Then the air line at the top of the pressure tank was closed, making an air cushion against which the water must be pumped to the pressure required and indicated on the pressure test gage above the air tank. All the water pumped into a drum, to raise and maintain a given pressure, was weighed and recorded, and the amount of actual leakage from each drum was carefully measured in a graduated glass for each pressure.

Drums Nos. 2, 5, and 6 offered almost perfect resistance to water pressures of 50, 100, and even 150 lb per sq in., only one stroke in from 10 to 20 min being required to maintain these pressures. The front, back, and side elevations of the drums, and the points at which moisture and leakage appeared at the surface of the concrete are shown in Fig. 1.

Under the head, "Saturation," in Table II is given the entire period of time allowed for absorption, which went on at a steadily decreasing rate per hour, usually becoming imperceptible after 20 hr. The weight of water absorbed under a head of 5 ft is given in the next column, while the columns following give the period of time, the total weight of water used to maintain the given pressure, and the rate per hour, including both the absorption and leakage in the total and in the rate per hour.

Table III gives the weight of the water absorbed by the concrete at all pressures and the leakage while under a pressure of 200 lb, for all drums except Drum No. 10, which was tested to a maximum of 125 lb. In this table the leakage per hour is calculated from the time of the falling of the first drop. Hydrated lime, equal to 10 per cent of the cement, had been added to Drums Nos. 5, 6, 9, and 10, marked "*L*" in the table. The area of the interior surface exposed to water was 125.7 sq in. in each drum.

Absorption under a pressure of 50 lb soon fell to a rate so low that more time would have been required for an adequate test than could be spared. The following rates of absorption were observed when a pressure of 50 lb was first applied: Drum No. 1, 0.5 lb in $1^1/_2$ hr; Drum No. 2, 0.125 lb in 1 hr; Drum No. 3, 0.25 lb in $1^1/_4$ hr. Under a pressure of 50 lb per sq in. leakage developed in only two drums. Drum No. 9 leaked 0.75 lb in 1 hr. At the first test Drum No. 10 leaked 0.25 lb in 3 hr, but at the second test it did not leak at all.

Position of Leaks and Moist Spots

The position of the leaks and moist spots in each drum, as shown in Fig. 1, has some significance. Except in the case of Drums Nos. 7, 8, 9, and 10, which have a mix of 1: $2^1/_2$: 5, they were mainly at the front, or the upper end in casting. This position of the leaks and moist spots was due mainly to the wires that held the reinforcement to the outside form while casting was taking place, and which were cut off at the surface. Also, it may have resulted, in part, from the fact that there was a slightly lower density of the concrete in the upper position in casting. However, in Drums Nos. 7 and 9, which also have a

Table III. Absorption and Leakage of Water per Drum

Drum No.	Composition	Period of Test: Hr	Period of Test: Min	Water Absorbed: Total Lb	Water Absorbed: Lb per Hr	Leakage: Total Lb	Leakage: Lb per Hr
		At all pressures from 50 to 200 lb per sq in.				At 200 lb per sq in. only	
1	$1:1^1/_2:3$	23	45	2.40	0.101	0.00	0.000
2	$1:1^1/_2:3$	23	15	0.81	0.035	0.00	0.000
3	1:2:4	26	5	8.00	0.307	0.75	0.237
4	1:2:4	27	20	8.94	0.327	1.00	0.250
4*	1:2:4	5	30	3.25	0.591	0.06	0.036
5	1:2:4*L*	26	40	5.88	0.220	0.03	0.009
5*	1:2:4*L*	25	30	4.25	0.167	0.00	0.000
6	1:2:4*L*	28	0	8.63	0.308	0.00	0.000
7	$1:2^1/_2:5$	26	30	22.00	0.830	2.00	0.667
8	$1:2^1/_2:5$	27	50	9.50	0.342	1.50	0.333
9	$1:2^1/_2:5L$	28	40	24.25	0.846	2.75	0.550
		At all pressures from 50 to 125 lb per sq in.				At 125 lb per sq in. only	
10	$1:2^1/_2:5L$	28	30	14.75	0.517	0.188	0.188
10*	$1:2^1/_2:5L$	25	20	8.00	0.316	0.00	...

* Indicates a second test. See Table II.

concrete mix of $1: 2^{1}/_{2}: 5$, several moist spots appeared in the back end, which had been the lower end in casting and which contained no wires extending to the surface.

In the six drums with a concrete mix of 1:2:4 or richer, there was only one moist spot or leak on the curved surfaces, shown at point F in Fig. 1. This was also the result of a wire's coming to the surface. The greater prevalence of leaks at the end may have been due to the fact that water followed the spiral reinforcement and then the wire to the surface.

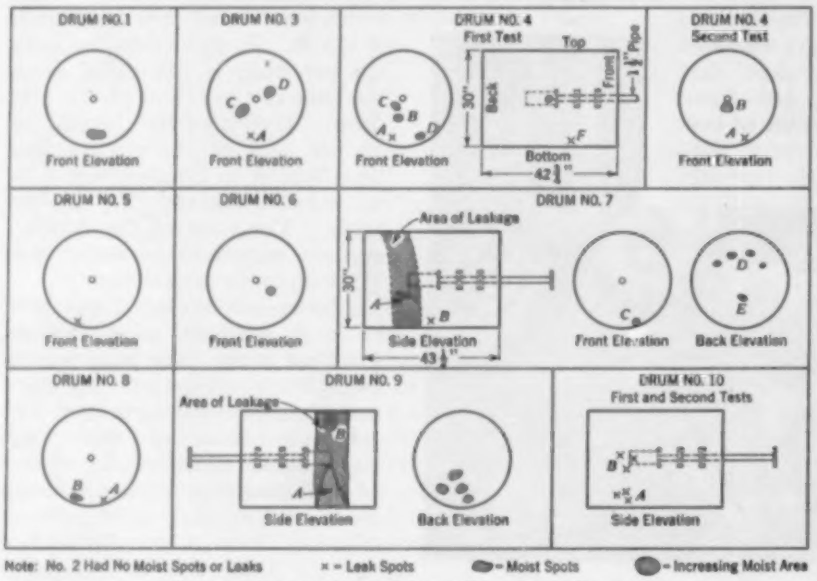


FIG. 1. LOCATION OF MOIST SPOTS AND LEAKS
In Concrete Test Drums Under Hydraulic Pressure

CONCLUSIONS

Leaks developed under a pressure of 50 lb in two of the four drums with a concrete mix of $1:2^{1}/_{2}:5$, both of which contained lime. My own practical experience has been that a mixture with a cement richness of 1:2:4 is necessary in order to secure water-tightness in reservoir and tank walls less than 2 ft thick, even at such light pressures as they are subjected to. The experiments showed little to indicate that a richer mix was needed under a pressure of 200 lb.

Results of the tests were distinctly favorable to the use of hydrated lime. While the concrete in the proportions $1:1^{1}/_{2}:3$ was water-tight without lime, it appeared that a mixture of 1: 2: 4 was equally tight when lime to the amount of 10 per cent of the volume of the cement was added. The lime caused the aggregate to flow more freely into place, and to form a more compact mass, for much the same reason that the bricklayer finds it easier to trowel a mortar of lime and cement than one of pure cement.

It was decided to adopt a concrete with a mixture of 1:2:4 or one of approximately those proportions. The $1:2^{1}/_{2}:5$ mixture was not sufficiently tight under a working pressure of 200 lb. It is true that Drum No. 10, which was of this mixture, with 10 per cent hydrated lime added, appeared to be tight at the second test under a pressure of 100 lb, but the moist area at the exterior surface steadily increased. Since the voids in the sand were 42 per cent, this 1:2:4 mixture gave approximately a 19 per cent excess of cement over voids. The voids in the broken stone were 44 per cent, and the excess of mortar over voids in the crushed stone was 22.7 per cent. Even with very careful workmanship, this excess is apparently necessary, in each case, to make up for imperfections of mix. The $1: 2^{1}/_{2}: 5$ mix, even with the addition of lime, gives no excess of cement and only about 14 per cent excess of mortar over voids in the crushed stone. When using hydrated lime, it has been found very important to avoid an excess of water, as this makes it difficult to secure an even mix.

The increased water-tightness of Drums Nos. 4, 5, and 10, on application of a second test, is significant. These drums were from 29 to 37 days old when the first test was applied. In the case of Drums Nos. 4 and 5, the second test was applied 16 days later, while in the case of Drum No. 10 the interval was only 6 days. Although Drum No. 10 was of a concrete mixture of $1:2^{1}/_{2}:5$, improvement was as marked relatively as in either of the other cases. Also this improvement appeared to be independent of the use of hydrated lime. At the second test, the very small amount of water absorbed under a 5-ft head is to be noted, as well as the lower rate of absorption at high pressures. It is possible that this was due to the fact that, during the first test, some of the finer particles were carried into the concrete and massed a little back from its inner face. Since there was an increase rather than a decrease in the rate of absorption and leakage as long as the pressure was applied during the first test, it must be inferred that the improvement would not have taken place had not the pressure been removed for a time. It is therefore concluded that, after the first test of the penstock and the application of pressure for 48 hours, the pressure should be released, and not applied again for two weeks in order to take advantage of the improvement in water-tightness.

CONTRIBUTING CAUSES OF LEAKAGE

As has been noted, some moist spots appeared where the wires, which were inserted to hold the reinforcement in place while casting, reached the outer surface of the drums. The water will show a tendency to follow the reinforcing steel bars unless all grease and loose particles of dirt and rust are first removed, as was done in the case of the supply pipe. Therefore no reinforcement should come nearer than 4 in. to the exterior surface of the lining. No reinforcing bars, bolts, pipe, or wire should pass entirely through the lining unless they have been carefully cleaned and provided with collars.

It has been decided that the minimum thickness of the penstock lining should be 2 ft in order to provide the resistance to crushing and shearing believed to be desirable for the conditions. A lining of that thickness of concrete can then be made water-tight under a pressure of 200 lb if it is composed of cement of a volume 20 per cent in excess of the voids in the sand; hydrated lime equal to 10 per cent of the volume of the cement; and mortar 20 per cent in excess of the voids in the crushed stone. This, with the addition of hydrated lime, would be approximately a 1:2:4 mixture. While the concrete lining must be mixed and placed with extreme care, it is found that the extra cost necessary to secure water-tightness will still leave a large saving over any other form of penstock suitable to withstand such a pressure.

The tests described here were carried out under the immediate supervision of Edwin J. Pickwick, of my staff.

Design of Steel Sheet-Piling Bulkheads

An Explanation of the Essential Theory Involved

By Raymond P. Pennoyer

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MORE bulkheads of steel sheet piling, especially for wharves and slips, are being built today than ever before. Such construction has the advantage of providing an unbroken front and a solid fill behind it. Rules of thumb and precedent have usually guided the design of such walls in the past, often resulting in extravagant weights and lengths of steel and improper anchorages. Some methods of determining proper earth pressures, length of piling, pile section, and loads on wales and tie rods appear in "Carnegie Steel Sheet Piling," a publication first issued in 1931. The author of this article, Mr. Pennoyer, was largely responsible for the preparation of that volume. He here presents in simple form an outline of the essential steps required in designing a safe and economical steel sheet-piling bulkhead.

AMONG the latest applications of sheet piling with high beam strength are breakwaters, jetties, canal locks, bridge abutments, piers, very deep cofferdams, sea walls, retaining walls, wharves, and slips. The introduction of deep arch-web interlocking sections, with their high beam strength or section modulus with a minimum of weight, has greatly enlarged the use of steel sheet piling for these permanent retaining walls or bulkheads resisting very heavy lateral loads of confined earth or water. Such construction is rugged beyond the hazards of ordinary accident, yet flexible, so that concentrated blows from moving vessels and severe wave action as well as ice action do it no damage.

Proper design of steel sheet-piling bulkheads involves several factors for the evaluation of which there is as yet no commonly accepted basis. There have been few failures, a fact which is considered a tribute to the common sense of the American engineer, but the best of judgment is not infallible. Precedent has served as a guide, and there are many bulkheads so designed as to be extravagant in weight of steel and cost. On the other hand, there have been a few, but very few, failures.

The outline of design procedure here presented is founded on simple assumptions and simple mathematics. The process is generally found acceptable to the engineering profession and gives results proved to be safe in practice. Many approximations are made, mostly for simplicity, but the results are believed to be sufficiently accurate in view of the inaccurate predictions as to earth loads in the basic assumptions. In Fig. 1 is given diagrammatically a section through a typical steel wharf or bulkhead, of which all the main parts are named.

PROGRESSIVE STEPS IN DESIGN

Certain essential data are necessary for design, as follows: depth of channel; height of freeboard; type of bottom, as indicated by borings; surcharge load, with its location in reference to the bulkhead line; and type of fill, including its weight, percentage of voids, and angle of repose. The treatment of lateral earth pressures on bulkheads differs from the treatment of such pressures on other structures in that it is necessary to develop primarily depth of penetration, bending moment, and tie-rod loads. There are many structures in service that were designed by the method here described. The problem is a study in four steps, of which only the fundamentals can be covered here. These four steps are:

1. Determination of lateral earth pressures and loads, with their distribution
2. Determination of the depth to drive the sheet piling and the location of the line of support
3. Determination of bending moment and selection of proper sheet-piling sections
4. Calculation of loads on wales and tie-rods

LATERAL EARTH PRESSURES

For steel bulkheads, the point of application and the direction of the lateral load are rarely of interest. In these respects they differ from retaining walls. The treatment of the earth pressures differs in that it is necessary in the case of bulkheads to develop the total pressures at given points, the lateral loads at the wale and at the bottom, and the distribution of the total lateral load over the bulkhead.

For lateral earth pressure the Rankine formula is the most satisfactory in all respects, especially in the certainty and simplicity of its application. This formula is based on the theory that the earth is a mass of granular

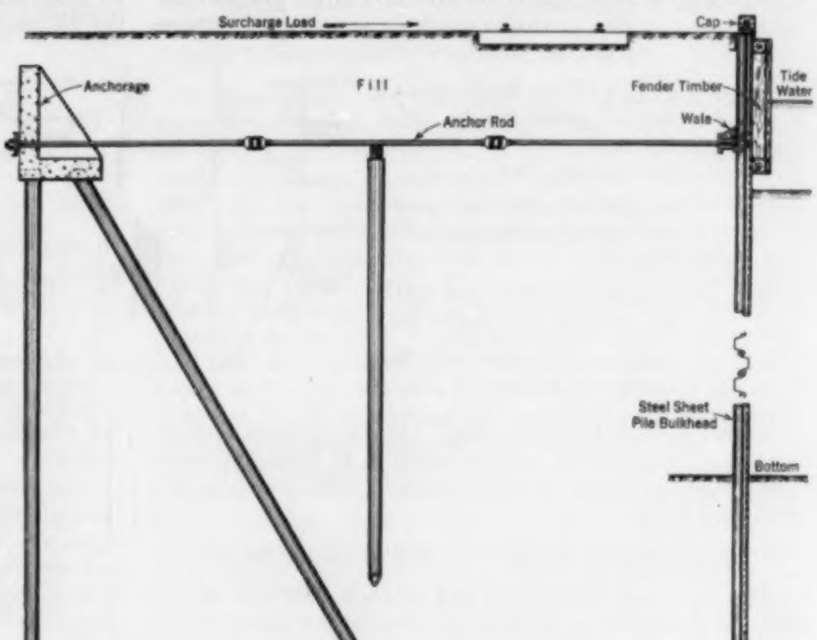


Fig. 1. Section Through a Typical Steel Bulkhead

particles without cohesion, which admittedly is rarely its actual condition. Unquestionably the lateral loads thus derived are greater than those generally encountered in practice, as has been proved by numerous tests. However, there is no way of predicting, in the laboratory or by theory, the action of water, frost, and vibration on an infinite variety of soils, combinations,

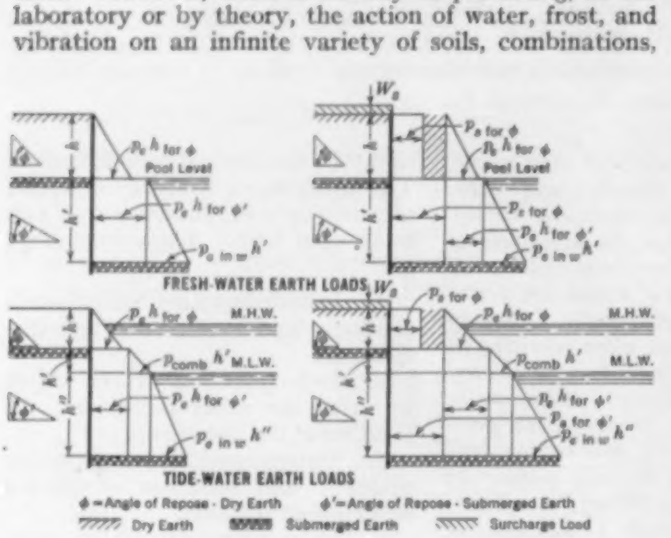


FIG. 2. LATERAL PRESSURES AND LOADS ON A BULKHEAD

and strata or their cohesion values as encountered in nature. The fact remains that these factors at times do cause the earth to act similar to a cohesionless, granular mass with resulting pressures closely approximating those derived by the Rankine theory.

By this method the weight of the earth is resolved into an equivalent lateral pressure. Thus

$$p_e = w_e \tan^2 (45° - {}^1/_2\phi) \quad . \quad . \quad . \quad . \quad . [1]$$

and if the earth is submerged and its weight partially balanced by the water on the other side, the lateral pressure is

$$p_{e\ in\ w} = w_{e\ in\ w} \tan^2 (45° - {}^1/_2\phi) \quad . \quad . \quad . \quad [2]$$

in which p_e = equivalent horizontal liquid pressure of dry or moist earth in pounds per square foot

$p_{e\ in\ w}$ = equivalent horizontal liquid pressure of submerged earth in pounds per square foot

w_e = weight of dry or moist earth in pounds per cubic foot

$w_{e\ in\ w}$ = weight of submerged earth in pounds per cubic foot

ϕ = angle of repose of the earth, in degrees

Throughout this article small letters are used to indicate unit weights (w) and increments of liquid pressure (p), whereas capital letters designate total weights (W) and total forces (P).

DETERMINING WEIGHT OF SUBMERGED EARTH

The weight of the submerged earth is obtained by deducting from the weight of the dry or moist earth the quotient obtained, by dividing 100 less the percentage of voids by 100, times the weight of water per cubic foot. The equivalent lateral liquid earth pressure, p_{equiv}, at any height, h, in feet, in pounds per square foot, is then

$$p_{equiv} = p_e\, h \text{ or } p_{e\ in\ w}\, h \quad . \quad . \quad . \quad . \quad . \quad . [3]$$

Also, the combined lateral pressures resulting from the submerged earth, not partially balanced by water on the other side, should be the lateral pressure of the submerged earth plus the hydrostatic pressure, or

$$p_{comb} = p_{e\ in\ w} + p_w \quad . \quad . \quad . \quad . \quad . \quad . \quad . [4]$$

in which p_{comb} = the increment of the lateral liquid pressure of combined submerged earth and water in pounds per square foot

p_w = the increment of the hydrostatic pressure in pounds per square foot equal to the weight of water in pounds per cubic foot

That this combined pressure is developed is demonstrated by Henry Goldmark, M. Am. Soc. C.E., in TRANSACTIONS, Vol. 86 (1923), page 1553.

USUAL EARTH LOADINGS FOR BULKHEADS

In Fig. 2 are shown the usual earth loadings for steel bulkheads in fresh and tidal waters, with and without surcharge loads, the symbols being the same as those previously defined. The lateral pressure due to surcharge is uniformly distributed (not liquid) over the depth of the wall and is derived as follows:

$$p_s = w_s \tan^2\left(45° - \frac{1}{2}\phi\right) \quad . \quad . \quad . \quad . [5]$$

in which p_s = horizontal pressure in pounds per square foot uniformly distributed

w_s = surcharge load in pounds per square foot

Observation indicates that in tidal waters the water level of the fill is fairly constant at about half tide, and consequently the combined pressure is developed for this elevation above minimum low water, and the lateral load extends throughout the remaining depth of the bulkhead. In fresh water, capillary action raises the water level in the fill from 12 to 24 in. above pool level, but it is doubtful whether hydrostatic pressures are developed by this difference in head.

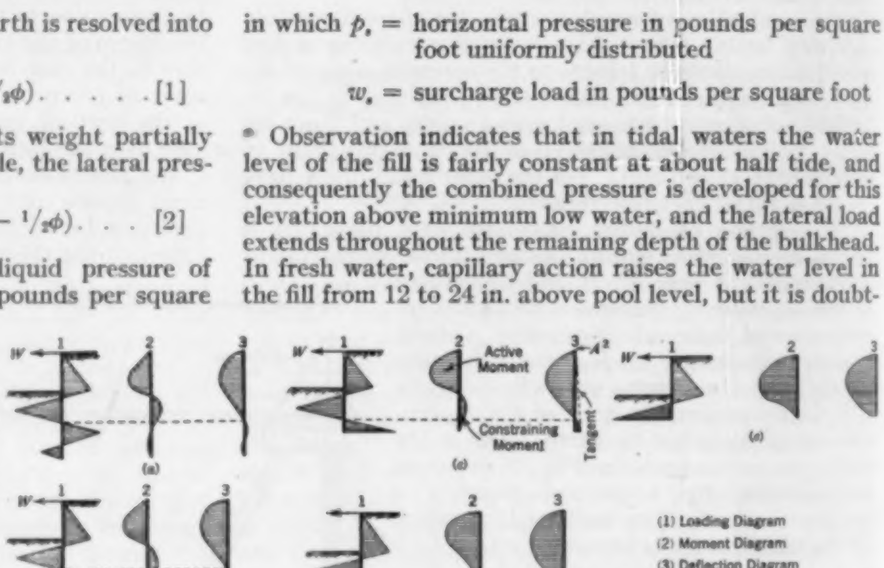


FIG. 3. LOADS, MOMENTS, AND DEFLECTIONS FOR STEEL SHEET PILES DRIVEN TO VARIOUS DEPTHS

The base of each geometrical figure indicates the pressure at that elevation of each element of the total pressure, and the latter is determined by adding these constituent pressures. The total lateral load, in pounds per foot of width, is represented by the areas of these figures. The distribution of the lateral loads over the depth of the bulkhead is also indicated by these figures. It will be noted that the angle of repose, ϕ, shown for the earth above the water line is different from ϕ', that given for the

submerged earth below. For sand, it is doubtful whether the two angles differ enough to affect the problem seriously, but for clays the angle of repose for the submerged earth may be very much less than the angle of repose for the dry earth. The method of using these diagrams will be outlined later.

HOW DEEP TO DRIVE THE PILING

Determination of the depth to which the sheet piling should be driven to prevent lateral movement at the toe has been a matter of precedent and experience. Failures have resulted because the piling was not driven deeply enough and, on the other hand, steel has been wasted because the piling was longer and more deeply driven than necessary. The mathematical determination of the proper depth is a problem peculiar to sheet piling.

Lateral movement of the bulkhead at the toe, due to the pressure of the retained earth, is prevented by the resistance of the soil to sliding laterally, to rising against the force of gravity, and to the breaking down of its cohesion. This resistance is calculated as a counter pressure against the base of the sheet piling and is called the passive pressure. This passive pressure is liquid, thus increasing directly as the depth. By the Coulomb law the increment is

$$p_p = w_e \tan^2 (45° + \frac{1}{2}\phi) \quad . \; . \; . \; . \; . \; [6]$$

in which p_p = the increment of the passive liquid pressure in pounds per square foot

w_e = weight of earth in pounds per cubic foot (use $w_{e\,in\,w}$ for submerged earth)

ϕ = angle of repose of the earth, in degrees

In Fig. 3 are shown the results of driving the sheet piling to various depths. If the sheet piling is driven to

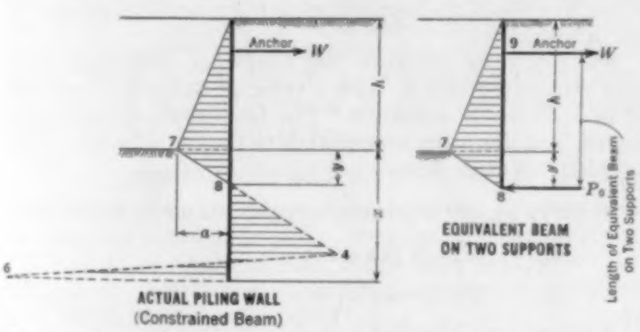


Fig. 4. How to Determine the Depth to Which a Sheet Pile Should Be Driven

an unlimited depth, as in Fig. 3 (*a*), the deflection curve has the form of the well-known damped vibration curve. In Fig. 3 (*b*), the wall is driven just deep enough so that there is no deflection at the lower end. In Fig. 3 (*c*), the lower end is displaced somewhat, making one point of contraflexure, and the tangent to the deflection curve passes through the point A_2. As the penetration is decreased, the constraining moment decreases while the active moment increases until a point is reached where the former vanishes and the latter reaches a maximum. This is illustrated in the cases shown in Fig. 3 (*d*) and (*e*). In case *e*, actual displacement occurs. In both cases, the wall acts as a beam on two supports.

A Steel Bulkhead with Anchorage, Tie-Rods, and Tie-Rod Supports in Place Before Backfilling

Somewhere between cases *c* and *d* the constraining action vanishes. Comparison with the different figures shows that the constraining moment is always less than the active moment, no matter how deep the piling is driven, and that the active moment is less in cases *a*, *b*, and *c* than in cases *d* and *e*, although the penetration must be greater.

There are two possibilities in deciding on the depth of penetration of steel sheet-piling walls:

1. Either the smallest possible depth of penetration may be chosen, in which case the bending moment, and therefore the necessary section modulus, is at a maximum;

2. Or the depth may be increased sufficiently so that the constraining action of the earth becomes effective. This reduces the moment but requires longer lengths of piling.

The material utilization factor equals the length times the square root of the maximum moment. This factor is nearly the same in both these methods; so that apparently neither has an advantage over the other. However, in the second possibility, which utilizes the constraining action of the earth, the anchor tension is less, and therefore the cost of the wales, tie-rods, and anchorage is also less. The greatest advantage of the second method is its greater actual safety, for if the sheet piling is driven only to the minimum depth, as in the first case, the factor of safety against pushing out at the toe is only unity, whereas the factor of safety of the steel is about 3. If too favorable earth pressures have been assumed, the wall will move outward at the toe.

If too favorable passive earth pressures have been assumed and the sheet piling is driven to the greater depth, the maximum effect is that the constraining moment vanishes and the active moment is increased, but not over 40 per cent. The factor of safety of the steel is reduced to 2 but the stress is still below the elastic limit, and the wall is absolutely safe against failure due to movement at the toe.

In order to determine the bending moment, it is necessary to locate the line of support or point of zero moment

of the piling in the earth. This reduces the problem to the study of a simple beam on two supports, these being the theoretical line of support and the tie or anchor rod. The active pressure is laid out as previously described, according to the Rankine method. Point 7 in Fig. 4 is the intersection of the active pressure line with the bottom. The location of Point 8 on the line of support is determined by the equation,

$$y = \frac{a}{p_p - p_{equiv}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad [7]$$

in which y = distance below bottom of line of support, in feet

a = active pressure at the bottom in pounds per square foot

p_{equiv} = increment of active earth pressure in pounds per square foot (for wharves $p_{equiv} = p_{e\ in\ w}$)

p_p = increment of passive earth pressure in pounds per square foot

In order to simplify the problem, the passive resistance of the earth below Point 8 may be replaced by a single force, P_0, acting at Point 8, thus reducing the study to that of a simple beam. This equivalent reaction, P_0, in pounds per foot of width of wall, is found by equating to zero all the moments about the point of application of the anchor at Point 9.

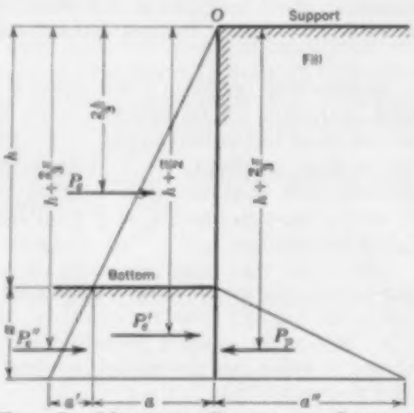


FIG. 5. MINIMUM DEPTH OF STEEL SHEET PILING TO PREVENT MOVEMENT AT TOE

The depth to which the sheet piling must be driven to take full advantage of the restraining action of the earth is obtained by maintaining a condition of equilibrium. This is done by so designing the bulkhead that the moment is zero at Point 8; that the loads on each side below this point balance; and that the moments about the toe balance. The depth of penetration, in feet, may be expressed by the equation,

$$x = K_2\left(y + \sqrt{\frac{6P_0}{2p_p - p_{equiv}}}\right) \quad . \quad . \quad . \quad . \quad [8]$$

in which x = depth of penetration below the bottom, in feet

y = distance below the bottom of the line of support, in feet

P_0 = equivalent reaction in pounds per foot of width

K_2 = a factor ranging between 1.1 and 1.2, which normally is 1.1 but may rise to 1.2 if the earth behind the wall is loose fill

Some authorities recommend for the undisturbed, compact soil (not fill) into which sheet piling is usually driven, that the increment of the passive pressure, p_p, as determined by the Coulomb formula, be doubled, as in Equation 8. Professor Franzius, of Hannover, conducted tests that seem to prove this assumption proper. His report is published in *Der Bauingenieur*, Vol. 10 (1924). The location of the line of support is then

$$y = \frac{a}{2p_p - p_{equiv}} \quad . \quad . \quad . \quad . \quad . \quad . \quad [9]$$

Another method of obtaining the proper depth of penetration, by taking moments around the anchor point, is outlined in Fig. 5, in which p_{equiv} equals the increment of the active lateral liquid pressure, in pounds per square foot, corresponding to P_e, $P_{e\ in\ w}$, or P_{cons} previously discussed, and in which

$$P_e = \frac{p_{equiv}\,h^2}{2}, \quad P'_e = p_{equiv}\,hx$$

$$P''_e = \frac{p_{equiv}\,x^2}{2}, \quad P_p = \frac{p_p\,x^2}{2}$$

Then,

$$P_p\left(h + \frac{2x}{3}\right) = P_e\left(\frac{2h}{3}\right) + P'_e\left(h + \frac{x}{2}\right) + P''_e\left(h + \frac{2x}{3}\right) \quad . \quad . \quad [10]$$

To solve for x, substitute assumed values for it until the equation is satisfied. For safety, the left-hand side of the equation should be equal to, or greater than, the right. This method theoretically develops only the minimum depth necessary to prevent movement at the toe, but it is to be noted that the increment of the passive pressure has not been doubled as in Formula 8.

DETERMINATION OF BENDING MOMENT

For determining the bending moment the graphical method is the most satisfactory and accurate. It is also possible to determine the depth to which the sheet piling must be driven in order to utilize to the maximum the constraining action of the earth and thereby develop the least maximum bending moment for a given lateral load. In this method it is necessary to construct a deflection diagram, which develops into a very intricate problem. The apparent accuracy of the method is of doubtful value in view of the approximate basic assumptions as to earth pressures.

For practical purposes the simplified graphical solution illustrated in Fig. 6 by a typical example is believed to be sufficiently accurate. The heights are noted in the figure, and the other essential data for the solution of the problem are as follows:

w_e (dry) = 100 lb per cu ft (voids in earth, 30 per cent)

w_w = 62.5 lb per cu ft

w_s = 500 lb per sq ft

ϕ = 30 deg, angle of repose of dry earth

ϕ' = 25 deg, angle of repose of submerged earth

$$\tan^2\left(45° - \frac{1}{2}\phi\right) = 0.333 \text{ (same for } \phi' = 0.406)$$

$$w_{e\ in\ w} = 100 - \left(\frac{100 - 30}{100}\right) \times 62.5 = 56.3 \text{ lb per cu ft}$$

$$p_p = 56.3 \tan^2\left(45° + \frac{25°}{2}\right) = 139 \text{ lb per sq ft}$$

$$p_a = 100 \times 0.333 = 33.3 \text{ lb per sq ft}$$

$$p_{a \text{ in } w} = 56.3 \times 0.406 = 22.9 \text{ lb per sq ft}$$

Distance of line of support below bottom, at Point 8

$$= \frac{940}{(139 \times 2) - 23} = 3.69 \text{ ft}$$

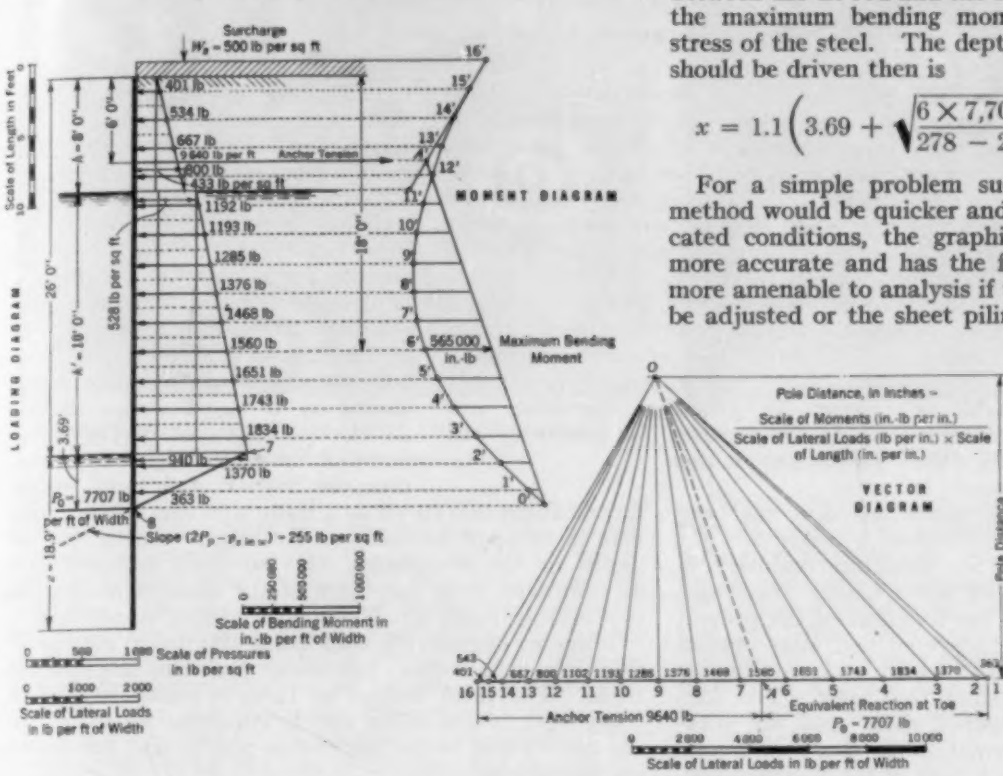


FIG. 6. GRAPHICAL DETERMINATION OF BENDING MOMENT AND ANCHOR LOAD
For a Wall of Steel Sheet Piling

All elevations, such as those of the wall, water tie-rods, and the bottom, are laid off to any common scale in feet. The diagram of the lateral earth pressure is constructed as previously described, to any scale in pounds per square foot. The total height of the wall, that is, the length of an equivalent beam, is divided into any number of convenient sections not necessarily of equal width. The total lateral load for each individual strip is found by scaling the mean pressure and multiplying by the width of the strip in feet.

CONSTRUCTION OF VECTOR DIAGRAM

A vector diagram is then constructed. On the base line, to any convenient scale, commencing at the right, the successive loads in each strip from bottom to top are laid off. Pole O is taken as the distance from the base line in inches and is equal to:

$$\frac{\text{Selected scale of moments, in inch-pounds per inch}}{\text{Scale of lateral loads, in pounds per inch} \times \text{scale of lengths, in inches per inch}}$$

All moments and loads are per foot of width of wall. Starting at O', lines parallel to the corresponding lines in the vector diagram are drawn to the intersection of each boundary line of the strips. These lines form the moment curve. Line $15'$–$16'$ at the top, parallel to 0–16 in the vector diagram, is continued to A', the intersection with the tie-rod line. A line is then drawn through $A'O'$.

Next, the maximum bending moment, in inch-pounds, is scaled off as indicated in Fig. 6. The moment in the cantilever section above the tie rod is negative and is maximum at the tie rod. This moment is found by scaling the distance from A' to the moment curve. The section modulus required in the steel sheet piling between the tie rod and the bottom is found by dividing the maximum bending moment by the safe working stress of the steel. The depth to which the sheet piling should be driven then is

$$x = 1.1\left(3.69 + \sqrt{\frac{6 \times 7{,}707}{278 - 23}}\right) = 18.9 \text{ ft} \quad . . . . [11]$$

For a simple problem such as this, the analytical method would be quicker and easier. For more complicated conditions, the graphical method is simple and more accurate and has the further advantage of being more amenable to analysis if the tie-rod elevation has to be adjusted or the sheet piling reinforced. A study of Fig. 6 will make this statement clear.

However, in most cases the analytical method is sufficiently accurate for use in practice and for a check on the graphical solution. The entire lateral load between the tie rod and the line of support, or between Points 8 and 9 in Fig. 4, illustrated by the total area of the geometrical figure, can be considered as uniformly distributed. The beam is treated as simply supported at Points 8 and 9. Designating the total lateral load per foot of earth as W lb, then the bending moment, M, in inch-pounds, can be expressed by the following equation, $M = \frac{Wl}{8}$, in which l is the distance between Points 8 and 9 in inches.

WALE AND TIE-ROD LOADS

Anchor tension can be determined analytically by equating to zero all the moments about the line of support, or Point 8, in Fig. 4. It can be determined graphically by drawing a line through Point O in the vector diagram, parallel to $A'O'$ in the moment diagram. The distance from 16 to A, the point of intersection, and that from 1 to A give, respectively, the magnitude of the anchor tension and the equivalent reaction, both in pounds per foot of width of wall.

ACKNOWLEDGMENTS

Indebtedness is acknowledged to Dr. Herman Blum, whose publication, *Einspannungsverhaltnisse Bei Bohlwerken*, not only checked, but carried to a much more precise conclusion, some of the methods first published in America in *Carnegie Steel Sheet Piling*, in the preparation of which I collaborated. Also, indebtedness is acknowledged to the *American Civil Engineers' Handbook* (1930), outlining the methods used by Frederic R. Harris, M. Am. Soc. C.E.; and especially to Charles O. Emerson, of the Carnegie Steel Company, who has worked with me for many years.

A Quarry as Viewed by an Engineer

Commercial Sandstone Produced in Large Quantities at Amherst, Ohio

By Edwin D. Cassel

Material Handling Machinery, Cleveland, Ohio

EFFORTS to obtain durable building material from the earth have led to the development of efficient yet simple equipment and organization. Stones for curbing, for flagging, for buildings, and for other purposes are produced at the large Amherst quarries of the Cleveland Quarries Company. The company employs up to 600 men, who are housed and fed on the site, to produce nearly a third of a million tons of commercial stone annually. In this article Mr. Cassel describes the principal operations and equipment required for quarrying and fabricating the stone.

To those who think much in terms of concrete aggregates, the quarry, the crusher, the screen, and the conveyor are almost synonymous terms. Yet, in the Cleveland district, a plant covering several hundred acres of quarry land and producing 300,000 tons of stone annually, has no such equipment. This is the sandstone operation of the Cleveland Quarries Company, at Amherst, Ohio.

Ohio cannot boast of marble or granite but it does produce limestone and sandstone. In the Cleveland district, sandstone is quarried at present in large quantities and has been produced commercially for more than a century.

The real development of the sandstone industry in this district, however, started some ninety years ago, when John Baldwin, one of the founders of the present Baldwin Wallace College, discovered and later opened the present quarry at Berea, which incidentally has been worked continuously since that time. The Amherst quarries, which were opened about 1869, are working the same geological formation as those at Berea. This formation is classed as a part of the Mississippian, or lower carboniferous rocks, by the Geological Survey of Ohio and is locally known as Berea grit. It starts in Adams and Scioto counties on the Ohio River and extends nearly due north to Norwalk and thence east to Elyria and Cleveland and to the Pennsylvania state line. The belt attains a width of 60 miles and ranges in thickness from about 24 ft to 250 ft.

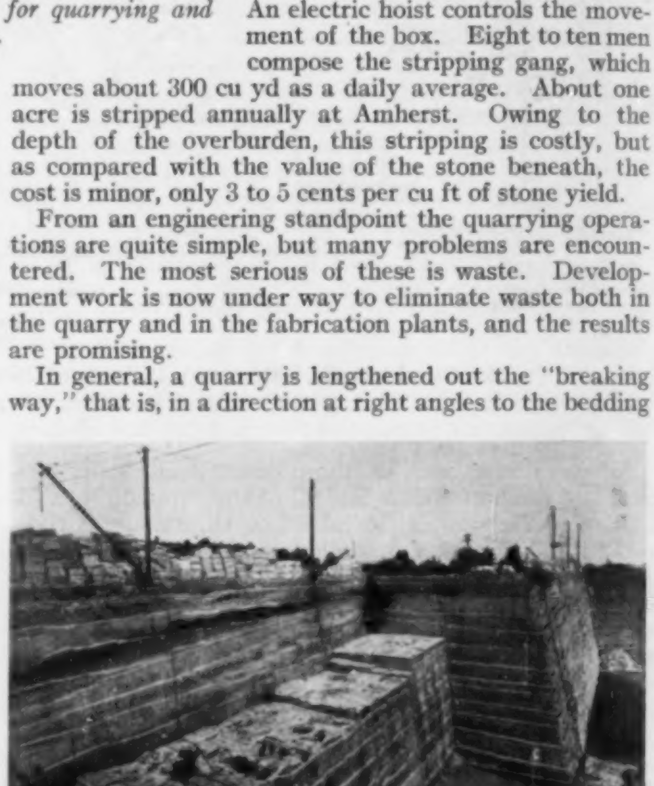
Stone of four different structures is quarried at Amherst, each with a name describing its characteristics. Split rock, as the name implies, splits readily. Distinct reeds or laminations parallel to the bedding plane are visible. It has been observed that in these layers the currents placed the longer axis of the sand grains parallel to the bedding plane. Spider-web rock is a type of split rock, but the reeds are not parallel to each other or to the bed, although they do follow a general direction. In cross-grain rock the reeds are distinct but have no regularity; they curve in all planes and change their direction rapidly. Liver rock is a homogeneous mass, without reeds or laminations, in which the sand grains have no definite orientation. An analysis of the stone from quarry No. 6, by Prof. D. J. Demorest of Ohio State University, shows the stone to be 92.15 per cent silica (SiO_2). It has a crushing strength of 8,000 or 9,000 lb per sq in. and a fusion point at about 3,000 F.

When viewed from the top of the bank, each quarry presents the appearance of the frustum of a hollow pyramid turned upside down, which effect is, incidentally, the result of operating necessity and not of design. The quarry site originally had about 40 ft of dirt and shale overburden. For the remainder of its depth, up to 200 ft in one quarry, solid sandstone occurs in layers from 2 to 12 ft thick.

Like most operations where man successfully wrests from Mother Earth her hidden treasures, the lines of least resistance are followed. When a quarry is first opened, the stripping is handled by shovel and cars to a dump. When the quarry reaches its full depth, a cableway is installed and the stripping is then dumped into the exhausted parts of the quarry. A 3-cu yd dump box is used for this purpose and is loaded by a $^3/_4$-yd steam shovel. An electric hoist controls the movement of the box. Eight to ten men compose the stripping gang, which moves about 300 cu yd as a daily average. About one acre is stripped annually at Amherst. Owing to the depth of the overburden, this stripping is costly, but as compared with the value of the stone beneath, the cost is minor, only 3 to 5 cents per cu ft of stone yield.

From an engineering standpoint the quarrying operations are quite simple, but many problems are encountered. The most serious of these is waste. Development work is now under way to eliminate waste both in the quarry and in the fabrication plants, and the results are promising.

In general, a quarry is lengthened out the "breaking way," that is, in a direction at right angles to the bedding plane and approximately parallel to the quarry face. In this plane the fracture is fairly true and regular. Broken in another direction the surface of the fracture is rolling and irregular and is called the "rolling way."

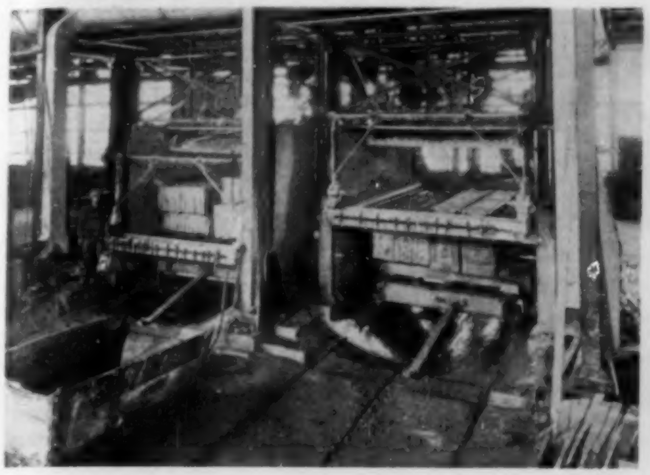


Partial View of Quarry No. 7, Amherst, Ohio

The Channeling Machine and the Channels Appear on the First Level. On the Left a Large Block Is Ready to Be Lifted

Channeling is the first operation in quarrying and is usually done well in advance of subsequent operations. First a channel is cut with a channeling machine as close

to the quarry face as the machine can get, to relieve the rock pressure. This distance is about 15 in. and accounts for the inverted pyramid effect. A parallel channel is cut from 25 to 27.5 ft from the quarry face, and cross channels are cut every 13 ft. The quarry face is usually stepped back from 50 to 55 ft at each cut. The channel cuts always extend down to the bedding plane, but in shallow deposits one or more beds may be cut through.



Gang Saws in Plant No. 4 of the Amherst Quarries
The Right-Hand Saw Is Beginning a Cut

Lifting of the stone from its bed follows the channeling and is accomplished by shooting or by plug and feather wedges. The kind of block, the type of bed, the location in the quarry, and the use to which the block ultimately will be put, determine the method. Some idea of the force exerted by the wedges is obtained from the fact that the blocks weigh up to 250 tons, not considering the cohesion of the block to its bed.

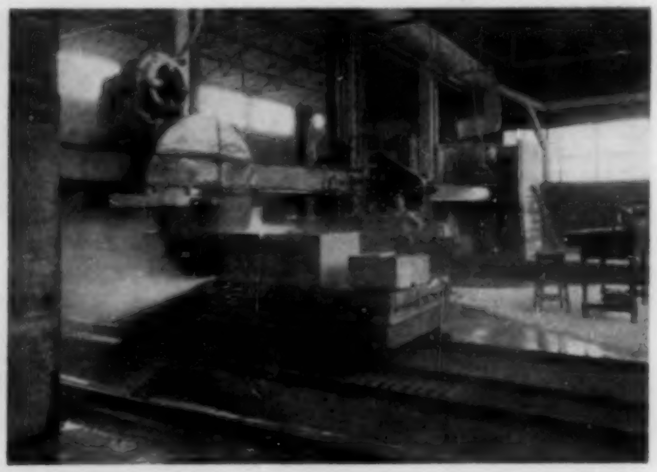
When the block is free on all six faces, it is drilled with jackhammers so as to outline 10 blocks 6.5 by 5.5 ft. Wedges are then employed to make the breaks. Splitting the block horizontally, or in a plane parallel with the bed, is called capping. When this has been done the stone is ready to be raised to the ground level.

Hoisting or raising is accomplished by large guy derricks operated by electric hoists and swings and proceeds at the rate of about 25 ft per min. Movement of stone on the quarry bed, when necessary, is also accomplished by the derricks, one of various hitches being employed to obtain a desired result.

Although a record lift of 40 tons was recently made, the usual weight of the blocks raised is from 5 to 10 tons. Arriving at the top, the block is either placed on a standard-gage flat car or stored along the track. Every safety precaution is taken and accidents are few.

SIMPLE EQUIPMENT UTILIZED

In itself the quarrying machinery is neither elaborate nor extensive. It consists of channeling machines, pumps, jackhammers, wedges, drills, and the usual hand tools. The channeling machine, though supplanted by other equipment in many places in the eastern part of the country, is still proving its value at Amherst. In appearance it resembles a locomotive of the late forties. It has a vertical boiler, now used as a heater for compressed air, and travels under its own power on its own tracks. Those at Amherst are capable of cutting, to any required depth, a channel as wide as 6 in. at the top. The vertical range of the machine is only 18 in.; hence bits must be changed every multiple of 18. As the bits lengthen, their cutting width decreases to avoid sticking. Three or five bits are used in the machine at one time as occasion requires. One machine channels from 18 to 40 sq ft to a 5 or 6-ft depth per hour.



Circular Carborundum Saws for Cutting Stone
These Saws Have Both Vertical and Polar Movement

Electrically driven centrifugal pumps of varying capacities are used. The amount of pumping required varies, but at certain seasons is considerable. The jackhammers are so constructed that the blow is straight down but the return has a slight rotary motion, which is imparted to the drill. The drills vary in size from $^1/_2$ in. to 2 in. Wedges are of the plug-and-feather type; the two feathers each have a plane and a cylindrical side. The plug, being a plane wedge, forces the feathers against the side of the hole.

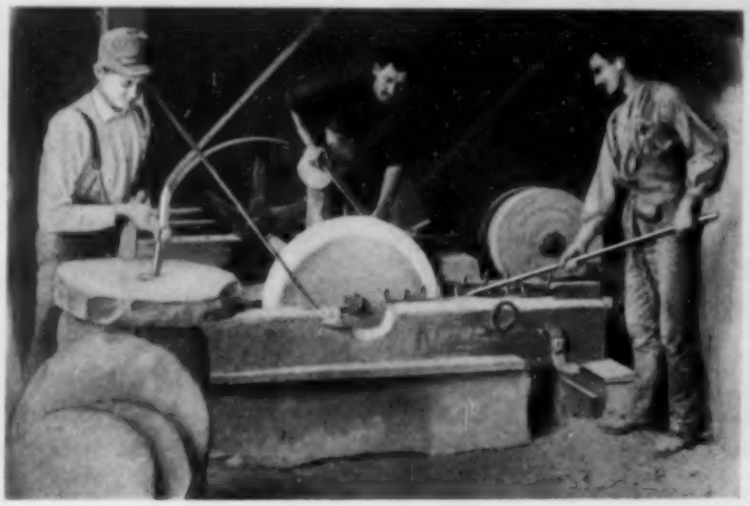
A general superintendent heads the organization. To him report the superintendent in charge of the production department, the master mechanic in charge of the maintenance department, as well as those responsible for the commissary and clerical departments. The quarry superintendents and plant superintendents report, in turn, to the superintendent in charge of production. In each quarry the rock bosses and channeling crews report to the quarry superintendent. The labor unit, whose activities center around a single derrick, is in charge of a rock boss. A head breaker and four other breakers, a driller, a signal man, and a hoist man comprise this unit. Its responsibility starts when the channels are made and ends when the stone is on the car.

At Amherst five quarries, covering about 800 acres, are being operated. These quarries are served by 12 miles of standard-gage railroad, 2 locomotives, and upwards of 30 flat cars. The 2,500-hp compressed-air plant—consisting of four compressors driven by two compound Corliss engines—is capable of producing 10,000 cu ft of air per min at 90-lb pressure. Air is distributed to all parts of the work through 12 miles of air line. A complete machine shop and a centralized blacksmith shop are provided. There are 40 derricks and hoists and 2,800 hp in electric motors. The quarries pass their product to 4 gang sawing plants, 2 curb planing plants, and a grindstone plant.

A gantry crane operating on 1,600 ft of track services the storage yard for the finished curbstone. In addition to this plant equipment, an operating and maintenance personnel of between 400 and 600 men is required. Practically this entire force is housed on the property in attractive and well-maintained houses and cottages and a hotel, run by the company, mostly for single men.

Maintenance work interlocks very closely with operation because of the frequent tool dressing required and the fact that the channeling machines, which play so important a part in the work, are no longer manufactured commercially and must be built and maintained at the quarry plant.

There is also an adequate and complete machine shop as well as a highly specialized blacksmith shop designed and built especially to satisfy the needs of the quarry and plant. It is equipped with two drop hammers, a pyrometer-controlled oil forge, oil furnaces, and compressed-air equipment for shaping and sharpening tools and drills. "Point 60 to 80" carbon steel is used for the tools and drills and is not tempered.



TURNING GRINDSTONES BY HAND

Workman on Left Is Making a Square Hole in a Rough Stone to Fit the Lathe Spindle. Cutting Tools, Hand Steadied by Pins, Shape the Stones

A wide and varied need is met by the fabricated stone, as is evidenced by the following list of uses: curbing; flagging for sidewalks and garden paths; grindstones; breakwaters (large quarry blocks); building stone (dimension stone); refractory linings for cupolas, both split and fabricated; acid-resisting linings for soaking pits; silica sand; and silica flour for fillers, 85 per cent passing a 200-mesh screen.

By far the largest market is for curbing, of which about 300 miles is produced annually at Amherst. The fabrication of building stone, a highly developed procedure and much of an art, is not done on the quarry site. The fabrication, at the quarry plants, parallels that of building stone and embraces all the operations but lacks the requisite accuracy and refinement. Fabrication includes splitting, gang sawing, carborundum sawing, planing, and turning. Splitting at the plant is done in the same way as the block is capped at the quarry, that is, with wedges.

Gang sawing, which follows splitting, is the most ramified single operation. The stone is transferred, by means of a high-speed crane, from the standard-gage car on which it is loaded at the quarry to a gang-saw truck, on which it is blocked and then run under the saws. Usually the cuts are made parallel to the bedding plane but all required cuts are made. As seen in one of the accompanying photographs, the foundations of the gang saws and the supporting steel framework are heavy. The saws themselves are usually built in units of ten. Each of the four columns supports a vertical screw and guide for a hanger block. Each of the two hangers supports two sway bars, which are fastened to each corner of the sash. The sash, which is a steel frame from 7 to 9 ft wide and from 14 to 17 ft long, holds the saws, 8 to 20 in number.

The sash is actuated in its reciprocating and slightly vertical motion on the hangers by a wood pitman 24 ft long. The pitman crankshaft, which rests on a separate heavy foundation, has a 22-in. throw, carries a large flywheel as well as a pulley, and is belted to the main drive-shaft. This drive-shaft operates 10 gang saws and is driven by a 400-hp motor.

A total vertical movement of about 7 ft is imparted to the sash by the vertical screws, at the sawing rate of 6 to 18 in. per hr. The saws themselves, 4-in. plain strips of "point 60" carbon steel $^1/_8$ or $^3/_{16}$ in. thick and equal in length to the sash, are held in the sash by wedges. The stone is sawed by the abrasive action of sludge and steel. The sludge is a 15 per cent mixture by volume of grit and water, the grit being silica sand and stone dust.

Three 4-in. centrifugal pumps keep the sludge moving to the saws, where it is spread over the surface of the stone and finds its way to the kerfs and thence to the sump to be used again. When the grit becomes too fine it passes over a weir to the waste flume. About 10,000 gal of water per hour pass over this weir to carry one ton of fine sludge.

For making single cuts, carborundum saws are used. These are similar to an ordinary circular saw, are 60 in. in diameter, and have carborundum teeth. Driven by a 50-hp motor they operate at from 700 to 900 rpm. They are supported on I-beams and saw the stone at the rate of 4 to 17 in. per min, depending on the depth of the kerf. Only water is applied in this operation.

Planing of stone is done in about the same way as planing of steel. A curb planer differs from an ordinary stone planer only in the bed, which itself has a rotary motion, so that the top, the chamfer or bull nose, and the face of the curbing may be planed at one setup. Curbing is both split and sawed and varies in width from 4 to 7 in. and in depth from 16 to 24 in. If split, it is planed about 12 in. on the face. Sixty pieces per planer per day is a recognized output. Twenty curb planers are housed in the two curb plants at the Amherst quarries.

GRINDSTONES STILL SHAPED BY HAND

Grindstones must meet fairly rigid specifications and for that reason the stone must be taken from the proper location in the quarry. They are made up to 8 ft in diameter and 13 in. thick and are turned in a special lathe. If made from sawed stone, the slab, of proper thickness, has a square hole picked through it the size of the lathe spindle. The circumference is also roughly outlined with the pick. The rough stone is then placed on the lathe spindle and turned by hand to the desired size. If the stone has been sawed it is shaped on the face only, otherwise on the sides as well.

Some experiments have been made in the mechanical turning of grindstones but as the grindstone is gradually being supplanted by its more consistent synthetic competitor, the carborundum wheel, the plant is content to use the method our fathers have used for this work for the past hundred years or more.

Grateful acknowledgment is made to the officers of the Cleveland Quarries Company for the use of the illustrations and other courtesies extended.

A Grade Separation Project in St. Louis

Tracks of Wabash and Rock Island Railroads Relocated and Depressed Through Forest Park

By L. R. Bowen

Member American Society of Civil Engineers

Chief Engineer of Bridges and Buildings for the City of St. Louis, Mo.

Particular study was given to landscape effects in planning the railroad grade-separation project carried out in Forest Park, St. Louis. It was found that marked economies could be secured by changing the alignment of the railroad and by forming "screening embankments" along its sides parallel to the tracks. These embankments absorbed the excess material from the excavation, required only partial removal of the old railroad fill, and interposed a visible screen and an actual barrier between the park and the trains.

During the fall of 1931 what is probably a unique type of railroad and highway grade separation was completed in St. Louis at a cost of about $650,000. It involved the relocation and depression of a double-track railroad system through the most developed section of Forest Park. Its interest lies mainly in the fact that elements of the work determined upon primarily from considerations of economy contributed materially to landscape effects in the park.

This project was the second unit in an extensive grade separation plan which had been a subject of controversy for many years between the City of St. Louis and the two railroads concerned, the Wabash and the Chicago, Rock Island and Pacific. Decisions of the Missouri State Public Service Commission and the state and Federal supreme courts had resulted in the acceptance of the general scheme of track depression within and adjacent to the park, thus clearing the way for the execution of the present work.

Forest Park is rectangular in shape, about 5,500 ft wide from north to south and 11,000 ft long. As shown in Fig. 1, it is bordered on the east by Kingshighway Boulevard and on the north by Lindell Boulevard. Union Boulevard and De Baliviere Avenue enter it from the north and cross Lindell Boulevard about 3,000 and 6,000 ft, respectively, west of Kingshighway.

Approaching Forest Park from the east the double tracks of the Wabash Railroad, after continuing some 3,000 ft in a cut, cross under Kingshighway Boulevard in a northwesterly direction through a 300-ft tunnel and enter the park at about the middle of its eastern side. After curving to the north nearly parallel with Kingshighway Boulevard, the tracks curve again to the northwest in a large sweep and become nearly parallel with Lindell Boulevard. Before this grade separation was built they passed out of the park in a northwesterly direction, crossing Lindell Boulevard about 200 ft east of Union Boulevard, and Union Boulevard about 140 ft north of Lindell Boulevard, both crossings being at grade. West of Union Boulevard the tracks curved again to the west and continued parallel with, and about 600 ft north of Lindell Boulevard to De Baliviere Avenue, which they also crossed at grade. The Rock Island Railroad used the Wabash tracks east of their crossing with Lindell Boulevard, but west of that crossing used its own tracks and right of way bordering the Wabash on the north. West of De Baliviere Avenue the Rock Island tracks continued parallel with Lindell Boulevard but the Wabash tracks curved to the northwest. The general plan and profile of the original and relocated tracks are shown in Fig. 1.

Before the grade separation was built the tracks entering the park at Kingshighway continued for 360 ft

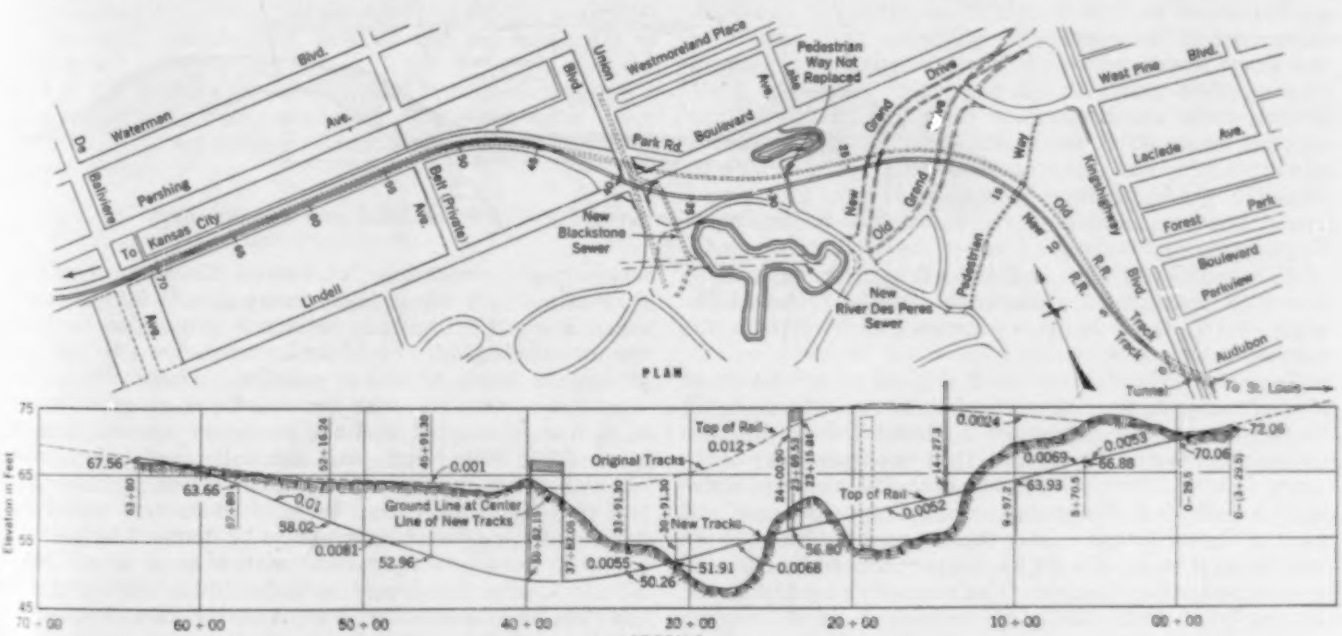


Fig. 1. Plan and Profile of Railroad Grade Separation at Union and Lindell Boulevards
Elevation of Boulevards Raised and Joint Tracks of the Wabash Railway and the Rock Island Railroad Depressed

in a cut, and then ran along the surface for a distance of 600 ft and were crossed by a pedestrian way. They were then carried above the grades of the park on an embankment for about 2,300 ft to within 400 ft of Lindell Boulevard, where they were again brought to the surface of the ground. Grand Drive, the main entrance to the park from the northeast, was carried

INTERSECTION OF LINDELL AND UNION BOULEVARDS, ST. LOUIS
Railroads Crossed at Grade near Intersection Before Separation

through the embankment about midway between Kingshighway and Union boulevards, the tracks being supported over the drive on an attractive railroad bridge. About 500 ft east and 900 ft west of Grand Drive stone arched passageways for pedestrians extended through the railroad embankment.

A separation of the grades of Lindell and Union boulevards from the tracks of the two railroads was the immediate object of the present undertaking, which was limited to the section east of De Baliviere Avenue since the Rock Island Railway was undecided as to the permanency of its occupation of its present right of way west of that thoroughfare.

TRACK DEPRESSION AT CROSSINGS FAVORED BY CITY

Consideration of the relative effects of track elevation and depression on the very important Union Boulevard entrance to Forest Park and the fine residence properties along Lindell Boulevard moved the city to favor lowering of the tracks at the crossings as far as practicable. This was made possible in the fall of 1929 by the completion, as far west as Union Boulevard, of the River des Peres sewer, which east of this point in Forest Park consisted of twin tubes 30 ft in diameter. The hydraulic grade of the sewer, however, limited the maximum lowering of the tracks at Union and Lindell boulevards to $13^1/_2$ ft, which necessitated a rise in the grades of these highways of $7^1/_2$ ft to secure a clearance of 18 ft over the tracks.

Because of the depression of $13^1/_2$ ft in the tracks at this crossing it was impracticable to raise them again to the level of the bridge over Grand Drive. It thus became necessary to rebuild that separation so as to carry Grand Drive over the tracks. This change naturally eliminated the pedestrian underpasses east and west of Grand Drive. Only the one east of Grand Drive was thought to be of sufficient importance to be replaced with a pedestrian bridge. The necessity of relaying the tracks throughout the park presented an interesting opportunity to develop landscape effects in the park.

The plan agreed upon by the city and the railroads contained the following provisions: relocation of the Wabash tracks through Forest Park by shifting them to the south about 50 ft, except near Union Boulevard where they were to be moved about 140 ft to cross directly under the intersection of Lindell and Union boulevards; combining of Wabash and Rock Island train movements between Union Boulevard and De Baliviere Avenue on one set of double tracks and shifting of their alignment west of Union Boulevard to bring them to the intersection of Lindell and Union boulevards; depression of the railroad tracks throughout the park to the low point at Lindell and Union boulevards and bringing them back to their original level west of Union

INTERSECTION OF SAME BOULEVARDS
With Tracks Depressed and Grade of Streets Raised

Boulevard at a point near De Baliviere Avenue; raising of Lindell and Union boulevards and Park Road, the connecting street between them, to levels high enough for proper clearance over the depressed tracks; relocation of Grand Drive in Forest Park; and construction of a pedestrian bridge east of Grand Drive.

Moving of the tracks so that they would cross under the intersection of Lindell and Union boulevards not only effected the economy of a single structure for the

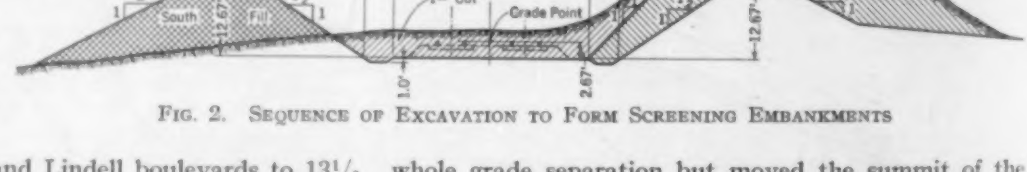


FIG. 2. SEQUENCE OF EXCAVATION TO FORM SCREENING EMBANKMENTS

whole grade separation but moved the summit of the necessary $7^1/_2$-ft rise in these streets a sufficient distance away from the abutting residence properties so that the approach grades could be brought down to the approximate levels of the properties. Where the boulevards were carried over the tracks, a circular intersection was adopted and the roadways around it were made 64 ft wide, with 12-ft sidewalks and balustrades of cut Bedford limestone. Although it was planned that the circle in the center, 48 ft in diameter, would be adorned with a fountain group, to be donated by private persons, it was temporarily treated as a flower bed. The lack of an obvious reason for the existence of the circle in this temporary state and the fact that automobiles had run over it led to its recent removal. The bridge for carrying the boulevards is of reinforced concrete and has two 30-ft spans to clear four tracks.

Shifting of the roadbed 50 ft to the south in the park was done to permit the operation of trains over the old tracks while the excavation for the depressed tracks was under way. This change saved the cost of temporary tracks and excavation of most of the old embankment, and provided work tracks from which ties, rails, and ballast could be placed directly in the new subgrade.

GRAND DRIVE RELOCATED

In this section of Forest Park the contour of the land is rugged. Grand Drive in its original location passed under the elevated tracks in a small depression, as shown by the profile in Fig. 1. The grade of the lowered tracks at this point is higher than the old level of the drive. Therefore, in the grade separation the drive was shifted

TRACK DEPRESSION COMPLETED
The "Screening Embankments" Were Later Sodded and Planted

about 400 ft to the west, where it would be on high ground and could be carried over the tracks without the use of a high artificial embankment. The reinforced concrete bridge for this drive has an over-all width of 80 ft and carries a roadway 56 ft wide. Its design is similar to that of the Lindell-Union Bridge and its handrails are likewise formed by cut-stone balustrades. Throughout the project all the roadway paving is asphalt on concrete foundations, and all the sidewalks are of concrete.

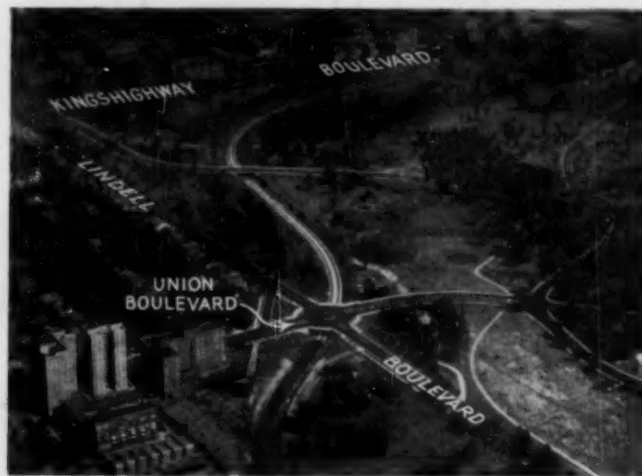
For the pedestrian bridge, steel trusses supporting a concrete floor were employed. Graceful lines were secured by using trusses of cantilever form with curved upper chords.

EXCAVATED MATERIAL FORMS "SCREENING EMBANKMENTS"

Some solution had to be found for the problem of disposing of the excess material, both that taken from the cut required for track depression and that contained in the old railroad embankment. Therefore it was decided to use "screening embankments" along the sides of the railroad through the park. These embankments, which were designed to balance the excess excavation, were each raised to a level of 10 ft above the railroad tracks and were made 10 ft wide at the top, with side slopes 2 to 1 on the park side, and $1^1/_2$ to 1 on the railroad side. A typical section is shown in Fig. 2. The north screening embankment was formed in the main by the old railroad embankment, which was reduced in section as required, but the south embankment was constructed entirely of new fill. Both were sodded as a part of the project, but the shrubbery on their sides was set out by the city at its own expense.

All the telegraph and telephone lines extending along the railroad through the park were collected in a single conduit and carried on a line of poles set adjacent to the tracks. The poles were made short enough so that they would not extend above the tops of the screening embankments.

It was agreed between the railroads and the city that



© Papin Aerial Surveys

COMPLETED GRADE SEPARATION AND TRACK RELOCATION IN FOREST PARK, ST. LOUIS

the latter would do all the work except the shifting and reconstruction of railroad tracks and facilities, which were to be done by the railroads, and that the joint cost of the work would be apportioned between the city and the railroads by the Missouri Public Service Commission.

Grading was done in two operations. The "first cut" to the new subgrade was made wide enough to allow the permanent tracks to be laid and trains routed over them, and then the "second cut," or remainder of the grading work, was done. Through the park the "first cut" was dug for as much of the width of the new roadbed as was possible without endangering train operations on the old embankment. The earth was deposited along the south side of the cut in the park to form the south screening embankment. Much of this grading was handled by a drag-line in one operation. West of Union Boulevard the Wabash Railway took up the old Rock Island tracks and shifted two of its own tracks to the north side of the old Rock Island right of way to allow room for the grading operations. These two tracks were then used by both railroads. The dirt from the excavation was carried into the park and wasted in the bridge approaches and the south embankment.

In undertaking the work it was necessary first to relocate and lower a sewer of 15-ft diameter in Union Boulevard to bring it below the new grade of the tracks. Construction of the bridges was commenced before the railroad tracks were laid in the new cut but was not finished until several months after completion of the grading work. The last work done was sodding, both on the approach fills for the bridges and on the screening embankments along the railroad tracks.

These embankments, which are the special feature of the project, form effective barriers between the park and the tracks, and largely hide the trains and railroad appurtenances from view. Because of the varying height of the embankments above the rolling level of the land in the park, they are not noticeably artificial. They will become much less so as the present planting program nears completion.

ENGINEERS' NOTEBOOK

From everyday experience engineers gather a store of knowledge on which they depend for growth as individuals and as a profession. This department, designed to contain practical or ingenious suggestions from engineers both young and old, should prove helpful in the solution of many troublesome problems.

Simplified Highway Construction Plans

By H. C. Hickman

Junior, American Society of Civil Engineers
Detroit, Mich.

Highway contractors often misunderstand and misinterpret the usual set of construction plans used by most highway departments, and numerous difficulties and mistakes occur. Highway construction plans, as generally drawn up, contain a key map, summary of construction quantities, mass diagram, plan,

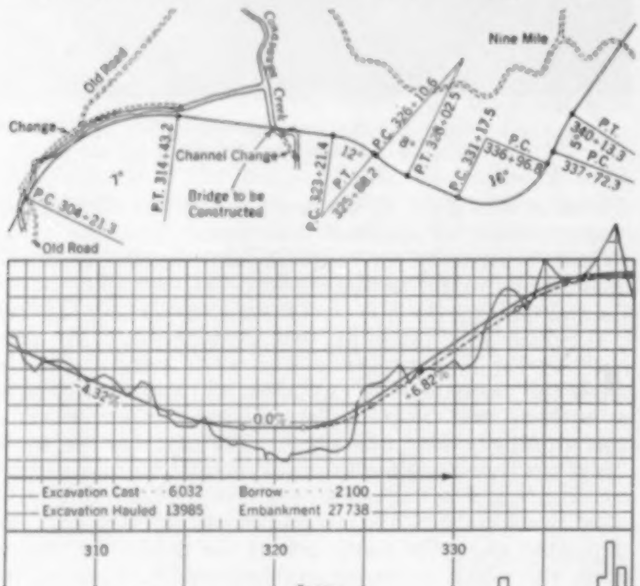


Fig. 1. Simplified Plans Used in Construction of Section of the Gilmer-Murray Highway, in Georgia
Distribution of Earthwork Plainly Shown

profile, and station cross sections. Everything the contractor needs is contained in these plans, but the data are often not sufficiently emphasized. Very few contractors realize the real value of the mass diagram even if they know how to use it.

The accompanying Fig. 1 shows part of the actual construction plan of a section of the Gilmer-Murray Highway, a 24-mile project connecting Chatsworth and Ellijay in north Georgia. This plan was developed by Carl F. Izzard, of the U.S. Bureau of Public Roads, Joel T. Daves, formerly of the State Highway Department of Georgia, and by me, for the purpose of organizing and compiling the necessary data for daily use by the contractor.

The plan is very simple and flexible. An alignment plan showing the stationing of the P.C.s and the P.T.s, the degree of curvature, and occasional landmarks on a scale of 1 in. to 500 ft gives a picture of the project in miniature. Directly under the plan, on a vertical scale of 1 in. to 50 ft, is drawn a profile which can be adjusted so that it coincides with the alignment The P.C.s and P.T.s, the profile of the ground, and the percentage of the new grade constitute a picture of the vertical alignment.

Under the profile, the earthwork distribution diagram is shown. Figures used in plotting are taken directly from the field notes. Neat line excavation and embankment quantities are plotted above and below the line, respectively, at each 50-ft station. The distribution and the yardage to be moved in each block are indicated by the dotted arrows. The number in parentheses is the average haul in stations. The cross-hatched lines indicate the areas of excavation which balance the embankment within the same 50-ft station. Borrow and waste are shown by detached blocks above and below the main diagram, respectively.

This plan is easier to draw up than the usual set of plans and takes less time. It affords a compact, simple picture of the important data used by the contractor in his work and can be used to great advantage on any grading project as a check on daily production and a progress chart.

Air Required by Air-Lift Pumps

By Francis Bates

Associate Member American Society of Civil Engineers
Consulting Engineer, Los Angeles, Calif.

According to popular conception, the explanation of the working of an air-lift installation for raising water is simply that the air pipe is submerged as deeply as possible in the liquid, the compressed air is loosened, and then "thar she blows." As a matter of fact, the expansion of the air follows the laws of permanent gases, and a theoretical solution of the amount of energy released is fairly simple.

Since air compressors are usually rated for capacity at sea level and at a temperature of 60 F, the basic formula for an air-lift pump should be for similar conditions. Hence, let

p_2 = atmospheric pressure (14.73 lb sq in.)

p_1 = absolute submergence pressure (gage + p_2)

V_T = theoretical number of cubic feet of free air required per gallon

The energy of the compressed air (w) is that of isothermal expansion from the pressure p_1 to the pressure p_2, the equation being

$$w = p_2 V_2 \log_e \frac{p_1}{p_2} \ldots\ldots\ldots\ldots\ldots\ldots [1]$$

Therefore, with W expressed in foot-pounds, the energy of one cubic foot of free air (V_2), expanding from p_1 to p_2 is

$$W = 144\ p_2 \log_e \frac{p_1}{p_2} \ldots\ldots\ldots [2]$$

Assuming the liquid to be water weighing 8.33 lb per gal, the foot-pounds required to raise one gallon a distance of h ft will be 8.33 h. Then, theoretically, the number of cubic feet of free air required per gallon will be

$$V_T = \frac{8.33\ h}{W} = \frac{8.33\ h}{(144)(14.73)\ \log_e \dfrac{p_1}{p_2}}$$

$$= \frac{h}{255 \log_e \dfrac{p_1}{p_2}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [3]$$

For more convenient handling, this is changed to the common logarithmic base and becomes

$$V_T = \frac{h}{(255)(2.3026)\ \log_{10} \dfrac{p_1}{p_2}} = \frac{h}{587\ \log \dfrac{p_1}{p_2}} \ldots\ldots\ldots [4]$$

Taking H ft as the submergence of the air inlet and substituting for the pressures p_1 and p_2 their equivalent water heads, in feet, the equation takes the familiar form of

$$V_T = \frac{h}{587\ \log \dfrac{H + 34}{34}} \ldots\ldots\ldots\ldots\ldots [5]$$

This is the base formula for computing the cubic feet of free air required to raise one gallon of water a distance of h ft, with a submergence of H, and represents an installation of 100 per cent efficiency at sea level. It is readily seen that this can be changed so as to apply to any liquid by substituting the actual weight per gallon and the equivalent heads for p_1 and p_2.

As is the case with any type of pump, an efficiency of 100 per cent is unattainable. The coefficient 587 is usually called C, and various values are assigned to it which represent the expected efficiency in percentage. That is, if C were 293, the pumping efficiency would be 50 per cent.

Our Readers Say—

In Comment on Papers, Society Affairs, and Related Professional Interests

River Discharge Formula Corrected

To the Editor: There seems to be some error in Dr. Chatley's formula as printed in your July issue, page 397. In the first place, the coefficient of kinematic viscosity of water at 20 C is 0.000001010 sq meters per sec which, for a pipe with a hydraulic radius of 1 m and a velocity of 1 m per sec, would make Reynolds' number VD/η = 3,996,000 (it would be exactly 4,000,000 at about 20.4 C). But as applied to channels, Reynolds' number is generally taken to mean VR/η (as, in fact, Dr. Chatley clearly stated in the next line below his formula). It would seem then that N should be 990,000 VR, or roughly 1,000,000 VR, instead of 4,000,000 VR.

Now consider a river for which $n = 0.030$, $V = 1$ m per sec, and $R = 1$ m. Calling $N = 4{,}000{,}000$ and substituting in the formula, $C = 48.4$ and $S = 0.000427$. If we call $N = 990{,}000$, we get $C = 44.6$ and $S = 0.000503$. With these data both Kutter's and Manning's formulas give $S = 0.000900$, and as they are known to be fairly satisfactory in this range there is evidently an error in Dr. Chatley's formula.

He speaks of this formula as conforming to the requirements of the Reynolds-Rayleigh law of dynamic similarity. If by this he means that it is dimensionally correct, I think he is mistaken. He makes C dimensionless (if n is regarded as dimensionless) while, as can be readily seen by solving the de Chezy formula for C, it should be of the dimensions $[L^{1/2}T^{-1}]$ or the square root of an acceleration.

Ralph W. Powell, M. Am. Soc. C.E.
Assistant Professor of Mechanics
Ohio State University

Columbus, Ohio
August 1, 1933

To the Editor: I appreciate Mr. Powell's comments of August 1. In my letter I omitted to include a note that "the characteristic dimension has been taken as four times the hydraulic radius so as to agree with the pipe investigations. N should be written VD/η instead of VR/η." This clears up the anomaly referred to in the first part of his letter.

As to his second point, the numerical value of C does depend on the square root of an acceleration (just as in the Ganguillet formula), and this fact is indicated by the words "metric units." If it is to be expressed in zero-dimensional form, the right side should be divided by $\sqrt{9.81}$ and the left side by $\sqrt{g}$.

Herbert Chatley
Engineer-in-Chief, Whangpoo Conservancy Board

Shanghai, China
August 30, 1933

Fulton Dam Tainter Gate Discharge

To the Editor: The lack of consistency in the results derived by Mr. Ripley in his paper, "Discharge Through Tainter Gate Openings," in the July issue, is due to the manner of derivation rather than any inherent fault in the data. The gate in question is not an orifice of free discharge, and the theoretical head should be measured to the top of the gate opening, rather than to the center.

In the accompanying Fig. 1 are illustrated the flow conditions through the gate opening at Fulton Dam for a head of 9 ft and a gate travel of 4 ft, as given in Table I of Mr. Ripley's article. The diagram at the left of the figure represents the forces acting on the outflowing prism of water. The total pressure in the direction of flow equals the area of the gate opening times the pressure head measured from the water surface to the center of the gate. However, due to the fact that the weight of the stream of water, after it has passed the gate, is fully supported by the bottom of the channel, there is a back pressure in the direction opposite to the flow. This pressure is equal in amount to the area of the gate opening multiplied by the pressure head equal to half the height of the gate opening. Thus the motion of water through the gate

TABLE I. RECOMPUTATION OF COEFFICIENTS FOR TAINTER GATE OPENING AT FULTON DAM, NEW YORK

(1) Travel of Gate on Rack In Ft	(2) Effective Velocity Head Measured from Water Surface to Top of Gate Opening, in Ft	(3) Theoretical Velocity Through Gate Opening Cu Ft per Sec	(4) Area of Gate Opening Sq Ft	(5) Theoretical Discharge Cu Ft per Sec	(6) Actual Discharge from Mr. Ripley's Measurements Cu Ft per Sec	(7) Coefficient of Discharge Disregarding Velocity of Approach	(8) Coefficient of Discharge Considering Velocity of Approach
1	8.23	23.01	20.6	471	360	0.76	0.76
2	7.62	22.14	36.8	779	620	0.79	0.76
3	6.90	21.06	56.0	1,180	890	0.76	0.75
4	6.15	19.89	76.0	1,512	1,200	0.80	0.78
5	5.35	18.54	97.4	1,805	1,425	0.79	0.76
6	4.54	17.09	119.0	2,035	1,650	0.81	0.77
7	3.62	15.26	143.5	2,187	1,604	0.73	0.69
8	2.71	13.20	167.7	2,250	1,800	0.80	0.74
					Averages........	0.78	0.75

is caused by the unbalanced pressure of the head measured from the water surface above the gate to the top of the opening.

The laws of discharge through openings of this type, under varying conditions of submergence, are discussed by Julian Hinds,

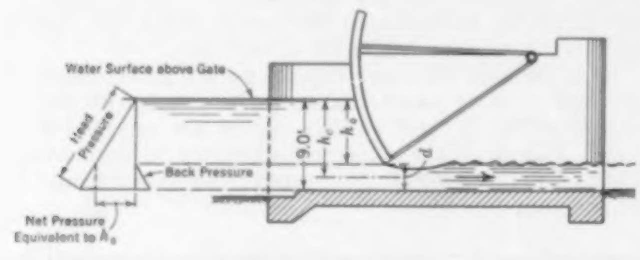


FIG. 1. FLOW CONDITIONS AT FULTON DAM, N.Y., FOR HEAD OF 9 FT AND GATE TRAVEL OF 4 FT

M. Am. Soc. C.E., in an article entitled "Rating Curves for Canal Head Gates," in the May 1922 issue of the *Reclamation Record*, and also by J. S. Longwell, M. Am. Soc. C.E., and Julian Hinds in an article, "Discharge Coefficients for Canal Head Gates," in the October 1919 issue of the same publication. Examples given in these articles illustrate the transition from free flow to submerged flow, as the outfall conditions change.

Where the velocity of approach is of definite value, the head due to that velocity should always be added to the computed or measured effective head. The coefficients calculated by Mr. Ripley have been recomputed on the basis of the head, h_o, Fig. 1, and the results are as shown in Table I in this letter. The coefficients in Col. 7 of Table I were computed with no allowance for velocity of approach. They are irregular, because of the approximate nature of the observations, as described by Mr. Ripley, but are considerably more consistent than the values shown in the original paper. An attempt to allow for velocity of approach gives the results shown in Col. 8. Except for the next to the last value in the column, the values are more uniform than those in Col. 7. Mr. Ripley may have additional information that will enable him to improve on the coefficients shown in Table I.

BEN GUMENSKY
Assistant Engineer, Metropolitan Water District of Southern California

Los Angeles, Calif,
September 19, 1933

Early Concrete Mixes of Excellent Quality

TO THE EDITOR: In connection with Dr. Mead's comments on early concrete specifications which appeared in the August issue, the impression may inadvertently have been given that the early specifications of the U.S. Bureau of Reclamation were deficient and that the resultant concrete may not have been comparable in quality to that used in present-day structures. It is my observation that this early concrete was of excellent quality and that the bureau's specifications, as well as contemporaneous concrete specification did provide for a proper proportioning of the ingredients.

The earliest specifications of the U.S. Bureau of Reclamation (1903) defined the proportions as one barrel of packed cement to seven barrels of mixed aggregate but also required experimentation to determine the best proportioning for the ingredients available. Some of these 1903 specifications expressed a preference for, but did not demand, machine mixing. In 1905, in the preparation of specifications for the Klamath Reclamation Project, we provided for definite proportions of cement, sand, and gravel for different qualities of concrete, and we also required machine mixing for all masses of concrete whose volume exceeded 100 cu yd.

Practically all of the older specifications provided specifically for the proportioning of ingredients though in less detail than is now customary. In Haupt's *Engineering Specifications and Contracts*, published in 1887, there are given several examples of concrete specifications, some of which date back to 1875, and all of which specify definite proportions of cement, sand, and coarse aggregate. It is of interest to note that one of these—a specification for a bridge foundation prepared by the Pennsylvania Railroad Company, in 1875—specifically required the sheer dropping of concrete from a height. This is generally not permitted now for fear of possible separation of the ingredients. Evidently the writer of the specification thought that such dropping would ensure a proper compaction of the concrete. The provision was as follows:

"The concrete must be placed in the foundation in layers not over a foot thick, and must either be thrown from a height of not less than ten feet, or else such layer must be well rammed until a film of water appears on the surface, but not enough to make it quake."

One of the earliest concrete jobs of which I personally had charge was the construction of some railroad bridge piers in 1896. The specifications for the concrete in these piers clearly provided for the proportioning of concrete ingredients, and these specifications had been standard on this railroad for some years. The required proportions, by volume, were 1 part of cement, 2 parts of sand, 3 parts of gravel, and 4 parts of broken stone.

JOSEPH JACOBS, M. Am. Soc. C.E.
Jacobs and Ober, Consulting Engineers

Seattle, Wash.
Sept. 18, 1933

Present Survey Data Should Be Used

TO THE EDITOR: In your August number, Major Bowie concisely described the very creditable achievement of the U.S. Coast and Geodetic Survey during the past century in establishing a precise survey control system covering a large part of the Nation. He might well have mentioned the fact that this governmental

agency has actively cooperated in making its information generally available.

The engineering profession has shown a certain apathy or lack of appreciation of the importance of making use of these data, especially in highway work. A certain county has recently completed a ten-million-dollar hard-surfaced road network. The plans for these roads refer to an arbitrarily assumed level datum formerly adopted at the county seat, despite the fact that the relation between this datum and sea level has been accurately determined and published. At very little, if any, added expense, these road plans could be based on sea level datum and bench marks established at suitable places, such as on bridges and culverts, and also ties secured to triangulation points. With this national survey control, road locations could be accurately plotted on the Clarke spheroid projections, in their true horizontal and vertical relation to other projects. The plans would be of much greater future value in making studies of water resources, power transmission lines, railroads, and other projects.

It is not, however, my purpose to single out a particular road system, because nearly the same comment is applicable to most highway projects. It is probably true that in the case of many isolated highway projects, ties to national survey control would not be of much assistance in the acquisition of right of way or in actual construction. But the general practice of securing these ties will result in a vast accumulation of useful data of ever-increasing value. The degree of accuracy of highway and railway surveys is generally sufficient for this purpose.

To illustrate, assume that an engineer is required to make a study of a certain valley for water-supply development or flood control, and that the highways and railroads traversing the valley are properly related by national survey control. Without field work, cross sections of the valley along the highways may be taken directly from their plans, and the valley width and slope determined. If it is necessary to make a map of the valley, the highway and railroad locations may be plotted to serve as control, with bench marks conveniently located. If maps of a part of the valley have been prepared previously, they may be incorporated with slight changes, but if they have not been properly related to the national survey control, they will be of but slight value.

The compilation of the control data along highways should be a function of the various state highway departments, in conjunction with the U.S. Coast and Geodetic Survey and the U.S. Bureau of Public Roads. Where Federal funds are contributed to any project, the Government may properly require the use of national control in surveys. During the past century a splendid system of national survey control was almost completed. In the coming century we should make full use of it.

Charles O. Boynton, Assoc. M. Am. Soc. C.E.
Field Engineer, Standard Oil Company

Kansas City, Mo.
October 5, 1933

Duluth Begins Sewage Treatment Works

To the Editor: Duluth's sewage disposal problem, described by Mr. Wilson, in the September number, is in a general way similar to the problems of some of the other cities on the Great Lakes where the water supply is obtained from the same body of water into which the sewage is discharged. Unlike Chicago, Duluth and Superior cannot readily divert their sewage flow into some other drainage basin by reversing the flow of the St. Louis River. As in Milwaukee and Cleveland, proper sewage disposal is of vital importance in protecting the safety of the public water supply. Also, as in those cities, it is not practical to dispose of the sewage except indirectly into waters used as a source of water supply. The dilution factor in Lake Superior is very high. Nevertheless, it has long been the opinion of health authorities that some better method of sewage disposal is essential to a satisfactory program of water treatment and in relieving both general and local nuisances.

The system described by Mr. Wilson contemplates the ultimate collection, and treatment at a single plant, of the sewage and the ordinary commercial and industrial wastes from the entire city, except for a somewhat isolated area in the west end. Final disposal will be into the harbor at a straight-line distance of about 11 miles from the water-works intake. The treatment of certain industrial wastes is, to a certain extent, a special problem and is to be dealt with separately. The project appears to be comprehensive, at least as regards the disposal of the sewage.

The site of the treatment plant is centrally located at the lower end of St. Louis Bay, which is in reality an inner harbor. Before reaching the lake proper, the river water into which the sewage will be discharged must first pass through a comparatively narrow channel into the Duluth-Superior Harbor from which it will enter Lake Superior. The construction cost of the first unit of this project is estimated by Mr. Wilson to be about $1,600,000, or approximately $20 per capita on the basis of the population actually served. He roughly estimates the annual charges at $160,000, or $2 per capita per year. These estimates include the cost of intercepting sewers and force mains.

This project, when completed, will offer a better safeguard to the public water supply than any of the other projects given serious consideration, as the actual place of discharge is 11 or 12 miles from the intake. Unfortunately, funds will not permit the completion of the entire project at this time. It is therefore proposed to intercept the sewage now being discharged directly into the lake by means of the works under construction and to convey it to a pumping station near the entrance to Duluth Harbor, where it will pass through screens with $^1/_2$-in. mesh, be chlorinated and discharged into the lake at a place about 8 miles distant from the water-works intake. This will undoubtedly improve the situation as regards the safety of the water supply, and will alleviate some of the local nuisances associated with the discharge of sewage through many individual outlets.

It is unfortunate that the financial situation makes necessary the use of these temporary means of disposal for a large part of Duluth's sewage. It is sincerely hoped that money will soon be made available so that the work can be finished and full benefits realized.

Because of their geographical position at the head of Lake Superior, Duluth and Superior should be materially benefited by the completion of the St. Lawrence Waterway. If these cities enjoy the substantial increases in population that it is predicted will result from the completion of this important project, the sewage disposal situation, unless taken in hand, may become much more critical than it is at present. It is well that Duluth has progressed as far as it has toward the solution of its share of the problem.

J. A. Childs, M. Am. Soc. C.E.
Chief Engineer, Metropolitan Drainage Commission

St. Paul, Minn.
October 6, 1933

The Cost of Education Should Be Reduced

Dear Sir: After reading the symposium on taxation, in the August issue, I feel that it may be pertinent to point out that none of the authors emphasized one conspicuous cause of burdensome taxes and that is the poor government of some of our states and most of our large cities. They are badly organized. In general, no agency exists for scrutinizing and coordinating the activities of these governments and for ensuring that their personnel be kept in reasonable relation to the work to be done. Employment in their service is treated as a political perquisite, and in many instances places on the public pay roll are given to persons who are not expected, and in some cases are unable, to perform any useful work. When to this is added favoritism, under lax laws, in the making of purchases, in the planning of public works, and in the award of contracts, for these works and the inspection of their execution, the result is a burden to the taxpayer, which might

readily be alleviated without any lowering in the standards of public service.

Some of these evils are matters of common knowledge. Many of them are peculiarly within the knowledge of engineers, who should not passively acquiesce in their continuance. This is, perhaps, merely a repetition of Mr. Goodrich's "taxation axioms."

There is one point on which it is possible to be specific, namely, education at public expense. Mr. Bane states that education accounts for 40 per cent of the taxpayer's dollar (in the community in which I live it accounts for over 50 per cent of it), and he infers that this expenditure cannot be cut without detriment. Those who have seen something of our public schools will question Mr. Bane's conclusion. Every educable pupil should have the opportunity to train his reasoning powers and access to the body of knowledge of history, literature, mathematics, and civics that will serve as a basis for such specialized further effort as each may desire to make at his own expense. But our schools should not go beyond this, and I doubt whether the elaborate buildings, equipment, and other paraphernalia that the school authorities now demand are justified by corresponding improvement in the civic standards of the beneficiaries.

School boards and the teaching profession should prove that the things for which they ask the citizen to pay are necessary and advantageous. Certainly, I have difficulty in believing, as I was once asked to do, that it is proper that manicuring and beauty culture be taught at public expense. There are undoubtedly other courses equally unjustifiable that are being pursued in our public schools. Pruned of luxuries and excrescences, school budgets can readily be reduced, and the pupils will benefit by being forced to concentrate their faculties on worth-while studies. "Snap" courses should be eliminated and elective courses reduced to a minimum.

CHARLES KELLER, M. Am. Soc. C.E.
Byllesby Engineering and Management Corporation

Chicago, Ill.
September 29, 1933

Evaluation of Highway Service

DEAR SIR: The article by Mr. Mehren, in the August issue, on keeping highway improvement sold to the public is very timely. Most significantly he says, "The most important feature of present highway operation is its economics. The day of emotional appeal is past. Hard business facts regarding the profitableness of the highway to the user will dominate highway planning from now on." The step that must now be taken is the compilation of the business facts to which he refers. As yet few attempts have been made to evaluate highways from this standpoint.

Aware of the importance of this problem, the Highway Research Board has undertaken a project which has for its objectives the enunciation of correct principles to govern the evaluation of general-use highway systems, the outlining of procedure, and the promotion of the actual evaluation of such highways in the various states. These things need to be done in order that the reports suggested by Mr. Mehren may be placed before the public.

The fact that the highway transportation system is not under a single ownership and management does not complicate the situation. The public owns and maintains the highway, for the use of which it charges certain definite rates. A general-use highway system is, in fact, a public utility, and its costs and earnings can be compared and its economic justification determined by the methods commonly applied to utilities. That the charges are paid by users through various kinds of taxes should not obscure the fact that they are earnings.

The relation of the physical characteristics of the highway to the operating costs of the vehicles is also important, for although vehicle-operating economies may not accrue directly to the state as owner of the highway utility, they will affect most of the citizens as users of vehicles. The basic relation to be investigated is that between the annual cost of the highways and their earnings. That will show, from a bookkeeping standpoint, whether the utility is being operated at a profit or a loss. Studies of the relations between the physical character of the roads and the costs of operating vehicles over them are also important, as they will tell whether or not the users are receiving fair value for their money.

Analysis of a given highway system, as contemplated for the project of the Highway Research Board, involves determination of four factors: (1) average annual cost; (2) annual earnings; (3) relations between the physical characteristics of the roads and vehicle-operating costs; and (4) highway transportation cost per vehicle mile for various sections of the system. Adequate traffic surveys are necessary for the determination of the second and fourth items.

These factors are equally useful in evaluating an existing highway service or in seeking justification for contemplated extensions and improvements. The object in making such analyses of costs and earnings is to be able to furnish the public, both as stockholders in the highway utility and as users of its service, with easily understandable statements concerning the financial condition of their property.

A general-use highway system should earn enough to cover its annual cost and should furnish transportation service at the lowest cost per vehicle mile consistent with adequate service.

ROY W. CRUM, M. Am. Soc. C.E.
Director, Highway Research Board

Washington, D.C.
September 29, 1933

Construction of Fireproof Piers

DEAR SIR: In the article, "Salvaging a Burned Pier," by R. T. Betts, in the October issue, emphasis is placed upon the fact of successful reconstruction in record time. The points that are brought out will certainly help in the reconstruction of similar projects destroyed by fire, of which there have been a great many in the past few years.

One particular feature that should have been especially emphasized was the change in the design of the framing supporting the lower deck of the pier. Mr. Betts points out that, in the reconstruction of the pier substructure, all longitudinal timbers except the fender system were omitted from certain areas. He also goes on to say that for the original deck system consisting of stringers, planking, and concrete, were substituted a 10-in. reinforced concrete slab for the main pier and an 8-in. slab for the bulkhead protected by a 2-in. asphaltic wearing surface. What I wish to emphasize in this connection is the fact of the omission of longitudinal timbers, which I believe to be largely responsible for the disastrous fires that have recently caused the destruction of so many piers. These longitudinal timbers create continuous pockets in which a fire travels from end to end of the structure and cannot be reached by streams of water from the hose lines of the fire-fighting forces.

A simple change in the design of the substructure eliminates these continuous longitudinal pockets and substitutes cross barriers in the form of heavy timber caps on top of the piles at intervals of 10 ft. This will absolutely prevent the rapid passage of fire along the under surface of the deck. These timber fire stops are an additional safeguard to prevent fire from traveling along the piling and bracing below the supporting cap pieces. They will also tend to stop the passage of fire in any inflammable liquids floating on the surface of the water under the pier.

My experience with concrete slabs for the decking in a pier on Staten Island shows that, in a few places, there is some liability to spalling of the under surface of the slabs, with consequent exposure of the reinforcing rods to the corrosive action of salt water and weather. The concrete slab, therefore, should be subject to regular inspection and repair in order to prevent serious crumbling as a result of this tendency to expose the reinforcing rods.

EARL W. HARRINGTON, M. Am. Soc. C.E.
Vice-President and Engineer, Manufacturers Mutual Fire Insurance Company

New York, N.Y.
October 5, 1933

SOCIETY AFFAIRS

Official and Semi-Official

Codes for the Construction Industry Under NRA

Basic Regulations for All Construction and Supplementary Provisions for Engineers Are Formulated

UNDER the NRA, construction has been classed as a basic industry to be administered under a general Code of Fair Competition. Subordinate to such larger classification will be the component parts of the construction industry, each with its own code of fair competition. In this latter category are included the codes for the Professional Engineer Division, Architects' Division, General Contractors' Division, Subcontractors' Division, and others, each of them in turn governing further subdivisions. Drafts of this basic code and also of the supplementary code dealing with the Professional Engineer Division are here given for the information of members.

Formulation of the basic code has been sponsored by the Construction League of the United States, with which the Society is affiliated. Many conferences were held before the code was in shape for recommendation to the Administrator of the National Industrial Recovery Act. When it emerged from the public hearing on September 6, certain further revisions were incorporated so that the code as here given is in the form submitted for approval of Government authorities and as it is to be supplemented by the Engineers' Code.

Likewise, the Engineers' Code has been subjected to much study and repeated revision by a special conference of national scope. In the form finally evolved, it was submitted to the Board of Direction and approved on September 25. Later, October 9, it was considered in public hearing in Washington. Its wording as it came from this hearing, but without official Government approval, is that given here in full.

Officers of the committee of the Construction League charged with the preparation of the basic code include Stephen F. Voorhees, Chairman, and John P. Hogan, Vice-Chairman, both Members Am. Soc. C.E.; and James W. Follin, Assoc. M. Am. Soc. C.E., Secretary. The conference formulating the supplementary code for the Professional Engineer Division was under the chairmanship of Carlton S. Proctor, M. Am. Soc. C.E.

Basic Code of Fair Competition for the Construction Industry

TO EFFECTUATE the policy or policies of Title I of the National Industrial Recovery Act during the period of the emergency, to induce and maintain the united action of all elements of the Construction Industry under adequate governmental or private sanctions and supervisions, to eliminate unfair competitive practices and to advance the public interest, to reduce and relieve unemployment, to improve standards of labor and living and otherwise to rehabilitate the Construction Industry, the following provisions are established as a Code of Fair Competition for the Construction Industry.

1. *Definitions*—The term "Construction Industry" as used herein is defined to mean the designing, the constructing, and the assembling, installing, and applying of manufactured parts and products of (*a*) building structures, including modifications thereof and fixed accessories thereto, intended for use as shelter; and (*b*) fixed structures and other fixed improvements and modifications thereof intended for use in industry, commerce, sanitation, transportation, communication, flood control, power development, reclamation, and other similar services required for the public welfare; and the term "Construction Industry" is further defined to include all persons who perform such functions, including without limitations those persons commonly known and sometimes defined by law, as architects, engineers, contractors, and sub-contractors. The term "person" as used herein is taken to mean a natural person, partnership, company, trust, trustee in bankruptcy, association, corporation, or agency. The term "employers" shall mean all persons who employ labor in the conduct of any branch of the Construction Industry as defined above. The term "employees" shall mean all persons employed in the conduct of any branch of the Construction Industry as defined above.

2. *Provisions Incorporated from National Industrial Recovery Act*—(*a*) Employees shall have the right to organize and bargain collectively through representatives of their own choosing, and shall be free from the interference, restraint, or coercion of employers of labor, or their agents, in the designation of such representatives, or in self-organization, or in other concerted activities for the purpose of collective bargaining or other mutual aid or protection.

(*b*) No employee and no one seeking employment shall be required as a condition of employment to join any company union or to refrain from joining, organizing, or assisting a labor organization of his own choosing.

(*c*) Employers shall comply with the maximum hours of labor, minimum rates of pay, and other conditions of employment, approved or prescribed by the President.

(*d*) This Code and all provisions thereof are expressly made subject to the right of the President in accordance with the provisions of Section 10(*b*) of the National Industrial Recovery Act from time to time to cancel or modify any order, approval, license, rule, or regulation issued with respect hereto under Title I of said Act.

3. *Minimum Wages*—Employers in the Construction Industry shall pay wages, (*a*) Not less than the minimum rate of wages for unskilled labor hereby established which shall be not less than forty cents (40¢) per hour unless the hourly rate for the same class of work on July 15, 1929 was less than forty cents (40¢)

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per hour in which case the hourly rate shall be not less than that of July 15, 1929 and in no event less than thirty cents (30¢) per hour, and furthermore, in any event.

(*b*) Not less than the minimum rate of wages for accounting, clerical or office employees hereby established as follows: $15 per week in any city of over 500,000 population, or in the immediate trade area of such city; $14.50 per week in any city of between 250,000 and 500,000 population, or in the immediate trade area of such city; $14 per week in any city of between 2,500 and 250,000 population, or in the immediate trade area of such city; and $12 per week in towns of less than 2,500 population. Population shall be determined by the 1930 Federal census.

(*c*) Nothing herein contained shall be construed to apply to employees whose rates of wages are established for specific projects by competent governmental authority (Federal, State or political subdivisions thereof) acting in accordance with law or to employees whose rates of wages are established by wage agreements now in force.

4. *Maximum Hours*—Employers in the Construction Industry shall not employ any employee, (*a*) In excess of the maximum average of forty (40) hours a week during a six months calendar period, or forty-eight (48) hours in any week in such period, or eight (8) hours in any one day, excluding employees engaged in professional, executive, administrative or supervisory work; those engaged in cases of emergency work requiring the protection of life or property, and those in establishments employing not more than two persons in towns of less than 2,500 population, which towns are not part of a larger trade area. Population shall be determined by the 1930 Federal census.

(*b*) Employers shall not employ accounting, clerical or office employees in any office or in any place or manner for more than a maximum average of forty (40) hours a week during a one-month calendar period, excluding employees in managerial or executive capacities and those in establishments employing not more than two persons in towns of less than 2,500 population, which towns are not part of a larger trade area. Population shall be determined by the 1930 Federal census.

(*c*) Nothing herein contained shall be construed to apply to employees whose hours of labor are established for specific projects by competent governmental authority (Federal, State or political subdivisions thereof) acting in accordance with law or to employees whose hours of work are established by wage agreements now in force.

4-*A*. *Area Agreement for Hours and Wages*—Minimum rates of wages and maximum hours of labor may be established nationally or for a region or locality by mutual agreements reached through bona fide collective bargaining between truly representative national, regional or local groups of employers and employees. In no event shall such minimum rates of wages be less than those established in Section 3 hereof, nor in any event shall such maximum hours of labor be more than those established in Section 4 hereof.

5. *Minimum Age*—An employer in the Construction Industry shall not employ any minor under the age of sixteen (16) years or under any greater age specified by law or competent governmental authority.

6. *Amendments*—Amendments to or revisions of this Code may be proposed by the National Administrative Committee or any national trade association or professional body representative of any recognized functional division within the Construction Industry and when approved in accordance with the provisions of the National Industrial Recovery Act shall become binding upon the Construction Industry.

7. *Administrative Committee*—To effectuate the purposes of this Code and of the National Industrial Recovery Act and to provide for administration and coordination within the Construction Industry, there is established a "National Administrative Committee" which shall consist of the Policy Committee of the Construction League of the United States, as that committee is from time to time constituted, and three non-voting members to be appointed by the Administrator of the National Industrial Recovery Act. This committee shall have authority to establish such sub-committees and state, regional or local committees, sub-committees or agencies with such delegated powers, as it may deem necessary, and this committee may at any time and from time to time require of any employer, trade association or professional body in the Construction Industry any information relating to wages of employees, hours of labor or other conditions of or in the Construction Industry pertaining to the provisions or the operation of this Code, and may, and at the request of the Administrator shall, from time to time present to him such information or reports as he may require; and this committee may, and at the request of the Administrator shall, present to him such recommendations, as to conditions in the Construction Industry as they may develop, as he may specify, together with such other recommendations as in the opinion of the committee may tend to effectuate the operation of the provisions of this Code or any supplemental code proposed or made a part of this Code or the policy of the National Industrial Recovery Act.

8. *Supplemental Codes*—It is intended that this Code for the Construction Industry shall be amplified and expanded by supplemental codes prepared and proposed by trade or industrial associations or professional bodies within the Construction Industry representative of the various functions of the Construction Industry or subdivisions thereof. Such supplemental codes shall, so far as possible, and subject to the general approval of the Administrator, be administered by administrative committees or agencies therein respectively established. Such administrative committees so established shall have the power to hear and to recommend adjustments or reconciliations of any controversy between or complaint made by any employers or associations thereof, who shall be subject to the provisions of any such supplemental code or codes. In the event that any such adjustments or reconciliations so recommended shall not be accepted by such employers, or associations thereof, such administrative committees shall, at the request of any party directly concerned, refer any such controversies or complaints to the National Administrative Committee hereinabove established, for appropriate adjustments by it. In the event that the adjustment or reconciliation recommended by the National Administrative Committee shall not be accepted by any party to the controversy or complaint, the National Administrative Committee shall, at the request of any party directly concerned, refer the matter to the Administrator who, at his option, may hear and determine any such controversy or complaint. Any adjustment or reconciliation of any such controversy or complaint determined by the Administrator shall be final and shall bind the employers, or associations thereof, involved in any such controversy or initiating any such complaint.

It is the spirit of the foregoing provisions that, so far as possible, controversies or complaints arising within any of the functional groups or subdivisions of the Construction Industry covered by a supplemental code shall be fully determined and adjusted by the administrative committees or agencies established in such supplemental code, and that, whenever the adjustments or reconciliations recommended by such administrative committees or agencies are consistent with reasonable compromise, recourse shall not be had or appeal made to the National Administrative Committee or to the Administrator.

Any such supplemental codes submitted by such functional groups or subdivisions of the Construction Industry shall provide for minimum rates of pay not less than and for maximum hours of work not more than the limitations established therefor in this Code.

Supplemental codes prepared by national trade associations or professional bodies within the Construction Industry may be submitted to the National Industrial Recovery Administrator by the National Administrative Committee herein established when consistent with this Code and other rules and regulations promulgated by the President and when within the spirit and purpose of the National Industrial Recovery Act, but nothing herein contained shall be construed to prevent a trade association or other representative group or body within the Construction Industry from submitting a code directly to the National Industrial Recovery Administration.

The construction industry under this and supplemental codes shall provide for the registration of all construction contracts and work projects in accordance with such rules and regulations as shall be established by the National Administrative Committee, and shall collect and collate facts and data in regard to the Construction Industry and shall provide for an equitable apportionment and distribution of the costs.

9. *Adjustments*—In the event that any buyer subject to this Code shall have contracted before June 16, 1933 to purchase goods, structures, or parts thereof at a fixed price for delivery

after that date and prior to the expiration of this Code, he shall make an appropriate adjustment of said price to meet any increase in cost to the seller caused by the seller's having signed the President's Reemployment Agreement or having become bound by any code of fair competition approved by the President; provided, however, that in view of the fact that construction operations customarily involve the furnishing of various goods and structures, or parts thereof by a continuous series of independent long-term contracts and agreements at fixed prices between various parties, such as owners (including government departments), builders, contractors, sub-contractors and others, such adjustments shall be contingent upon similar appropriate adjustments to be made by all other parties thus participating, from and including the initial vendor of such goods and structures or parts thereof to and including the owner of the works or structure upon which they are used.

10. *Bid Peddling Prohibited*—The practice of "Bid Peddling" by any person as defined in Section 1 of this Code is an unfair trade practice and is prohibited by this Code. Furnishing to any bidder or other person, either directly or indirectly, at any time prior to the publication of the bids, any information, statement, or intimation relative to his own bid, to the bids of others, or to the awarding authority's own estimate is prohibited.

Bidding Practices—The following bases of contractual agreements are recognized as fair trade practices; guaranteed price, cost of work plus a fee, unit price, lump sum, and other contractual methods not inimical to the public interest, providing that the regulations contained in this Code of Fair Competition are met.

It is recognized that the preparation of a bid is a service involving an expense to the bidder, therefore, inviting and receiving of an unreasonable number of bids results in an economic waste. It is recommended that invitations to bid should not exceed six (6) in number.

Wherever the designation "awarding authority" is employed, this refers to architects, engineers, contractors, sub-contractors, or other persons who may award contracts or purchase materials for construction purposes and these, therefore, are to carry out all the requirements enumerated below.

(*a*) Prequalification of competency of bidders to perform the work involved is imperative. No contractor, sub-contractor, furnisher of material or equipment, as the case may be, shall be permitted to bid unless he has demonstrated to the awarding authority that he is competent technically and financially to perform the work.

(*b*) There shall be no collusion between the awarding authority and the seller, nor between the different sellers in the preparation of any bids, nor shall the awarding authority use any bid which he has reason to believe is at or below cost; but where this question arises, the purchaser must give the seller the opportunity of demonstrating by cost sheets or other methods, the correctness of the bid that he has submitted, if he desires its consideration. Collusion in any form is to be considered an unfair practice under this Code and is prohibited.

(*c*) An awarding authority inviting bids shall make available complete plans and/or specifications and other pertinent information in order that the bidder may prepare a complete estimate or bid in accordance therewith.

(*d*) An awarding authority shall designate a specific hour and place for receiving and opening of bids. All bids shall be sealed and signed by the bidder or his duly authorized agent. Bids received after the opening of bids shall be returned unopened. Bids received by the awarding authority from uninvited bidders shall be returned unopened.

(*e*) Supplemental codes shall require that the code authority for each trade shall provide a depository for duplicate bids, and shall require that all bidders file sealed copies of their bids, and any revisions thereof, with such designated depository.

(*f*) The awarding authority shall make an award or reject all bids, or obtain an extension of time from the bidders, within twenty (20) days after the opening of bids and shall make such award to a bidder, at his original bid price, who has complied with these rules.

The right to reject all bids is reserved to the awarding authority. Where all bids are rejected, bids shall not be again invited or submitted previous to the elapse of ninety (90) days from the date of such rejection, except there be a substantial change in the plans and/or specifications amounting to at least ten per cent of the previously estimated cost of the work; or, except that there shall be such a marked variation in the bids submitted from the awarding authority's estimate as to the valuation of the work as would indicate to the owner the necessity of new bids in order to secure fair competition. In such contingency the awarding authority, with the consent of the owner, may secure new bids for such work.

(*g*) The awarding authority in issuing his invitation to contractors on lump sum proposal, will require the list of sub-contractors whom the contractor intends to employ for every division of the work to be submitted with his bid. If, however, the awarding authority does not approve any particular sub-contractor submitted by the contractor, he may reject that bid, but he shall use the bid of some other sub-contractor who has already bid on the work, and the contractor's bid may be increased or decreased in the amount between the bid used and the one rejected. If a contractor uses in his proposal the bid of any sub-contractor for any division of the work, in the event that he is awarded the contract, and if he receives the approval of the awarding authority, he is to award the contract for this particular subdivision to said sub-contractor without further bids for the class of work to be done. Where the contractor contemplates doing the work of any particular subdivision with his own forces, and is qualified to do so, he will so state in his proposal.

All sub-bids should be delivered to contractor 24 hours prior to the delivery of bids to the awarding authority; copies of all such sub-bids shall be delivered at the same time to the various sub-contractor depositories. They shall be opened and made available to the bidders at the same hour as the opening of the lump sum proposals by the awarding authority.

(*h*) Where a contract is to be executed on other than a competitive basis; such as, cost plus a fee, the owner or his representative shall have the right to approve the list of sub-contractors to be invited to bid, and to approve the sub-contractors to whom the work is to be awarded.

(*i*) Every rebate, refund, allowance, discount, commission, or service privilege in whatever form shall be extended by vendor to every purchaser under like terms and conditions.

All supplemental codes shall provide for the enforcement of the provisions of this Section 10.

11. *Administrative Expense*—All employers and persons as defined in this Code shall bear their equitable share of the expense incident to the administration of this Code of Fair Competition under such rules and regulations as may be approved by the President under Section 10 (*a*) of Title I of the National Industrial Recovery Act.

12. *Effective Date*—This Code shall become effective on approval by the President of the United States and shall be applicable to all construction work undertaken pursuant to contracts entered into or otherwise commenced after such approval date.

Code of Fair Competition for the Professional Engineer Division of the Construction Industry

Preamble

THE AMERICAN SOCIETY of Civil Engineers, organized in 1852, a national association representing the Profession of Civil Engineering, pursuant to the intention of the Engineering Profession, in so far as the practice of the engineering profession is a function of the Construction Industry, to cooperate with the President of the United States in effectuating Title No. I of the National Industrial Recovery Act, during the period of the emergency, hereby recommends and submits for approval pursuant to Section 3 of said Title, the following Code of Fair Competition covering relations between professional engineers, clients or employers, employees and others in respect to all construction work; this Code having been approved by duly authorized representa-

tives of the following professional engineering organizations:

American Society of Mechanical Engineers
American Institute of Consulting Engineers
American Association of Engineers
American Society of Heating and Ventilating Engineers
American Society of Municipal Engineers
New York Association of Consulting Engineers
Structural Engineers Association of California
Chicago Structural Engineers
New York State Society of Professional Engineers
Oregon Technical Council
Western Society of Engineers
Connecticut Society of Civil Engineers
Florida Engineering Society
Rochester Engineering Society

In submitting this Code for the approval of the President and in tendering their agencies for the enforcement thereof, the American Society of Civil Engineers and the other organizations indicated above as in approval of this Code, declare that

a. They are truly representative of the engineering profession in so far as it is functional to the Construction Industry;

b. They impose no inequitable restrictions on admission to their membership;

c. This Code will not permit monopolies or tend toward excessive fees or wages, but will tend toward fair fees and wages, and the eradication of unethical and unfair practices and unfair competition between engineers, and toward the establishment of better professional standards of practice;

d. This Code is intended to eliminate unfair competitive practice and to advance the public interest and engineering standards, and to improve standards of working conditions and living, and effectuate the spirit of the policies set forth in the National Industrial Recovery Act.

ARTICLE I—THE GENERAL CODE

The Code of Fair Competition for the Construction Industry, as approved by the President of the United States, is adopted and made a part hereof and shall be attached hereto, and any provisions of this Code of Fair Competition for the Professional Engineer Division of the Construction Industry which may be inconsistent therewith shall yield thereto.

ARTICLE II—DEFINITIONS AND FUNCTIONS

Professional Engineer.

In the meaning and application of this Code a professional engineer shall be considered to be, and include, an individual, partnership, or corporation legally operating in responsible charge of the design or supervision of construction work;

Or a person in the employ of the same and who is registered or licensed in accordance with the provisions of law to practice engineering, or any subdivision thereof, within any State or Territory of the United States;

Or any person admitted to, or eligible by reason of technical training for admission to membership in any national, state, or regional professional engineering organization, in grades which require, as a constitutional provision, active practice as an engineer for not less than eight years and responsible charge of engineering work for not less than one year; active practice and responsible charge of engineering when functional to the construction industry to embody the direction, design or coordination of engineering works as a professional practice in which responsible charge in engineering teaching may be construed as responsible charge of work; graduation in engineering from a school of recognized standing shall be construed as equivalent to four years of active practice and the satisfactory completion of each year of work in such school without graduation shall be considered as equivalent to a half-year of active practice; graduation in a course other than engineering from a college or university of recognized standing shall be considered as equivalent to two years of active practice; provided, however, that no person shall receive credit for more than four years of active practice because of educational qualifications.

In the meaning and application of this Code the functions of a professional engineer shall include the planning, design, coordination, and supervision of construction, of engineering structures; the economics of, and the use and design of, materials of construction and the determination of their physical qualities; the investigation of the laws, phenomena, and forces of nature, when any of the same are involved or employed in connection with fixed works for any or all of the following divisions or subjects: irrigation, drainage, water power, water supply, flood control, inland waterways, harbors, municipal improvements, railroads, highways, tunnels, airports and airways, purification of water and sewage, sewerage, refuse disposal, foundations or substructures, framed or homogeneous structures, buildings, and bridges, and the supervision and coordination of the design and execution thereof. They shall include the investigation of, the design of, and the selection of, the force resisting and load-supporting members of structures, such as foundations, walls, columns, beams, girders, slabs, trusses, and similar members; and the investigation of, design of, and selection of mechanical, electrical, or sanitary component parts of structures; where such investigation, design, and selection requires a knowledge of engineering laws, formulae, and practice, a knowledge of the physical properties of the materials used, and a knowledge of the methods used in their installation. It is recognized that the functions of an architect include elements of a like nature to the elements included in the engineer's functions. Such normal functions as practised by architects shall not be deemed to be included in the foregoing statement of the functions of an engineer. Such normal functions of an architect being excluded, any one performing any of the above defined services, or undertaking to provide or to be responsible for such services shall be deemed an engineer, subject to all of the conditions of qualification and experience in the above definition of a professional engineer, and subject to all conditions and regulations of this Code.

Where a Professional Engineer registration or license law is in effect, any registered or licensed professional engineer shall be entitled to practice as an engineer but shall not be relieved by that fact from any of the provisions of this Code.

Professional Engineers are entrusted with financial undertakings in which their honesty of purpose must be above suspicion; they act as professional advisers to clients and in collaboration with employers and their advice must be absolutely self-disinterested; they are charged with the exercise of judicial functions as between client and contractor and must act with entire impartiality; they have moral responsibilities to their professional associates and to their subordinates; finally, they are engaged in a profession which carries with it grave responsibilities to the public, and as such, when functional to construction work constitutes a division of the Construction Industry.

Where used hereinafter the word "engineer" shall be construed as an abbreviation of the term "Professional Engineer" as herein defined.

Engineering Assistant.

In the meaning and application of this Code an engineering assistant shall be any person who, not registered or licensed by any state or territory to practice engineering as a profession, and not eligible for membership as hereinbefore defined in any professional engineering organization providing for membership as hereinbefore described, is employed to render technical or other services of a sub-professional nature under the direction of an engineer.

Person.

A person as used herein shall include any natural person, partnership, association, corporation, trust, trustee, trustee in bankruptcy, receiver, or agency.

Client.

A client shall be a person who engages the services of an engineer on a fee basis.

Employer.

An employer shall be any person, who engages the services of an engineer or an engineering assistant on a salary or wage basis.

Employee.

An employee as used herein shall mean any individual person employed by an engineer.

Contractor.

A contractor shall be any person contracting to perform the work

called for by the engineer's plans and specifications.

Article III—Required Provisions

Employees shall have the right to organize and bargain collectively through representatives of their own choosing, and shall be free from the interference, restraint, or coercion of employers of labor, or their agents, in the designation of such representatives or in self-organization or in other concerted activities for the purpose of collective bargaining or other mutual aid or protection;

No employee and no one seeking employment shall be required as a condition of employment to join any company union or to refrain from joining, organizing, or assisting a labor organization of his own choosing;

Employers shall comply with the maximum hours of labor, minimum rates of pay, and other conditions of employment, approved or prescribed by the President.

Modification—This Code and all the provisions thereof are expressly made subject to the right of the President, in accordance with the provision of Clause 10 (*b*) of the National Industrial Recovery Act, from time to time to cancel or modify any order, approval, license, rule or regulation, issued under Title I of said Act, and specifically to the right of the President to cancel or modify his approval of this Code or any conditions imposed by him upon his approval thereof.

a.—Minimum Wages.

No engineer or engineering assistant, employed on a salary or wage basis, shall be paid less than the minimum rates which are established regionally or locally by mutual agreements between truly representative groups of employers, and employees or as established or approved by the National Control Committee, as defined in Article VI, with the aid of its subordinate regional, state or local committees, and approved by the President, as provided by Section 7 (*b*) of the National Industrial Recovery Act. The minimum rates shall be at least those required by Article 3—"Minimum Wages" of the "Code of Fair Competition for the Construction Industry."

b.—Maximum Hours.

Maximum working hours for engineering assistants shall be 35 per week as an average over any six months' or lesser period of employment; with 48 hours in any one week and 8 hours in any one day as a maximum to meet emergency conditions.

c.—Age Limit.

Engineers shall not employ any one less than sixteen years of age, except that persons between fourteen and sixteen may be employed for not to exceed three hours per day between 7 a.m. and 7 p.m. on such work as will not interfere with hours of day school.

d.—Stabilization of Employment.

Engineers shall administer their functions so as to provide the maximum practicable continuity of employment to those in their employ. To this end the National Control Committee, through cooperation with other national professional engineering organizations, will furnish such data, reports of investigations and suggestions to the National Recovery Administration as may aid in bringing about a greater stabilization of the industry.

Article IV—Regulations Governing Relations Between Engineers and Their Clients or Employers

For the purpose of enforcing the provisions of this Code no engineer shall proceed with an engagement involving a fee of $1,000 or more, without first entering into a written agreement with his client, and such agreement shall be kept and made available on demand for inspection by the National Control Committee or its delegated representatives.

Violation of this "Code of Fair Competition for the Professional Engineer Division of the Construction Industry" shall justify cancellation of relations by a client, dismissal by an employer or discipline by the National Control Committee and/or prosecution at law under the provisions of the National Industrial Recovery Act.

An engineer shall not:

a. Acquire, own, or otherwise benefit by the purchase, sale, or ownership in any real estate or business interest which may be affected by any work for which he shares responsibility, except with the full knowledge and consent of his client or employer.

b. Own stock in, or have other interest in, or in any way benefit from the business of a contractor employed on any work for which the engineer shares responsibility, except engineers on a salary or wage basis, and they only with the full knowledge and consent of their employer.

c. Accept any pay or commission, except as clearly stipulated in his contract or terms of employment, for the use of any materials, patented device, appliance, or method employed on the work.

d. Accept any fee or gratuity for engineering or other services rendered to any contractor or sub-contractor engaged on the work for which the engineer is engaged as the client's or employer's representative, or accept compensation, financial or otherwise, for services in connection with such project, from any person other than his client or employer. Nothing herein shall be construed to operate against the prevailing and good practice by contractors and sub-contractors of engaging engineers, other than the engineer of record for the work, to render engineering services to them in connection with their engagement as contractors or sub-contractors.

e. Specify, direct, invite, or accept engineering designs, studies or sketches from a contractor, sub-contractor, or supplier of materials, interested in the work or in bidding on any element of the work, where such are services herein defined, or defined in his agreement with his client or employer, as being the responsibility and duty of the engineer. This does not debar the customary shop and working drawings, made by contractors, after the award of contract to them, for the work to be executed by them, nor the use of technical trade information issued by producers for the information of engineers.

f. Give any rebate, discount, bonus, fee, or commission in order to reduce his fee, or in order to influence or procure employment on a salary or wage basis.

Article V—Unfair Practices

To maintain fair minimum salaries and wages for engineers and engineering assistants the National Control Committee with the aid of its subordinate regional, state or local committees, shall, within four months after the effective date of this Code, recommend for the approval of the President, schedules of fair minimum rates for all types of engineering services functional to the Construction Industry. In arriving at these schedules the National Control Committee shall endeavor to approximate rates generally equivalent to the average minimum rates which obtained in each region at the beginning of the year 1929.

To assure fair competition and prevent rendering of services by an engineer in private practice below cost of production, plus overhead, insurance, and incidental expenses, and to insure fair bases for the determination of cost-plus-fee terms of employment, the National Control Committee shall develop, with the cooperation of its subordinate regional, state and local sub-committees, standards of cost accounting with uniform methods of determining overhead, inclusive of principal's time and other chargeable items, subject to the approval of the Administrator.

To maintain fair minimum rates of charge for the various branches of engineering practice functional to the construction industry and to avoid price-cutting among engineers in private practice, but without any attempt at price-fixing, the National Control Committee with the aid of its subordinate regional, state or local committees shall recommend for the approval of the President, schedules of fair minimum charges, where practicable. The recognition of such minimum schedules shall in no way operate against any engineer whose training, experience, reputation, or specialized practice, justifies a higher schedule of charges.

In the operation of this Code, before the establishment of engineering fees as above described, no engineer shall charge for his services, an amount, based upon the total cost of the work on which his services are rendered, less than that specified in the "Manual of Engineering Practice; No. 6. Charges for Engineering Services" adopted by the American Society of Civil Engineers, September 1930, which is appended hereto.

If the character of the work requires architectural or other specialized services not included in the functions of an engineer, as hereinbefore defined, it is the engineer's duty to recommend specialists for employment by or on behalf of the owner and to coordinate their work.

When any person undertakes to provide engineering design or engineering services he shall be deemed an engineer in the meaning and application of, and functioning under this Code, and as such shall make a separate and distinct charge for such designs or services as a separate account, said charge to be not less than the usual or prescribed professional charge made by engineers for such engineering designs or other engineering services.

In order to eliminate unethical and unfair competitive practices that violate sound public policy and proper professional procedure:

a. An engineer shall not enter into fee, salary, or wage competitive bidding with other engineers for a professional engagement.

b. An engineer shall not offer or provide free or contingent preliminary engineering services or free preliminary cost estimates, in competition with any other engineer whose services have been retained for the work as evidenced by a signed agreement.

c. An engineer employed in a salaried position on full-time basis shall not solicit or accept employment outside of his salaried duties in competition with other engineers, nor authorize the use of his name for the solicitation of such work. He may serve in a consulting or advisory capacity with the consent of his employer.

d. No person shall perform or undertake to furnish or be responsible for engineering services unless he is qualified by education, experience and organization and as herein defined.

The engineer shall not be a party to the unfair practice of trading one contractor's bid against another's in an attempt to reduce the amount of a bid, nor shall he induce secondary bidding, nor in any other manner engage in or sanction the unfair practice known as "bid peddling."

The engineer shall observe the rules of fairness in making known all requirements for the work for which he is responsible and shall furnish adequate information to all bidders alike. The engineer shall not submit his design drawings and specifications for contractor's bid until he has developed adequate preliminary information and essential pertinent data. He shall permit the contractor to satisfy himself as to the adequacy of the engineering information given and the practicability of the type and method of installation shown on the engineer's design and covered in his specifications. The engineer shall definitely establish in his design and specifications, the amounts of tolerance in positions, levels, dimensions, or weights which will be permissible, and shall include definite provisions for remedial measures, if such tolerances are exceeded.

The engineer, where so engaged, shall provide adequate and sufficient field supervision and inspection of the work and shall at all times be ready to accept or reject any part of the work as the installation proceeds.

Arbitration according to recognized practice or established federal or state laws shall be accepted as the approved method for adjudication of disputes, after decision by the engineer, and precedent to action at law.

ARTICLE VI—ADMINISTRATION

Amendments.

Amendments or revisions to this Code may be proposed by any truly representative professional engineering organization providing for membership as hereinbefore described, acting through the National Control Committee hereinafter defined.

National Control Committee.

To effectuate the purposes of this Code and provide for administrative control within the engineering profession in so far as it is a function of the construction industry, a National Control Committee shall be established composed of one member appointed by each of the following national professional engineering organizations providing constitutional requirements for membership as hereinbefore defined in Article II: American Society of Mechanical Engineers, American Institute of Consulting Engineers, American Association of Engineers, American Society of Heating and Ventilating Engineers, American Society of Municipal Engineers, and of eight members of the American Society of Civil Engineers appointed by the President of the Society. Members of the National Control Committee shall serve without salary in the administration of this Code.

Subject to the approval of the Administrator this control committee shall have authority to make all needful rules and regulations for the administration and enforcement of the provisions of this Code. This control committee shall have authority to establish such sub-committees and such subordinate local, state and regional committees and to prescribe such duties, rules and regulations as are deemed necessary to carry out the purposes of this Code and of the National Industrial Recovery Act.

In the establishment of each such state committee (or where there is no state committee, in each regional committee), there shall be one representative, for each state, from the recognized existing or hereafter created state professional society, in which membership in contingent upon legal admission to the practice of engineering within that state. Such representative shall be designated by such recognized State Society.

The National Control Committee shall coordinate its acts with the administrative agency established under the Code of Fair Competition for the Construction Industry.

Administration Expense.

Each engineer subject to the jurisdiction of this Code and accepting the benefits of the activities of the National Control Committee hereunder shall pay to the same his equitable share of the amounts necessary to pay the cost of assembly, analysis and publication of reports and data, and of the maintenance of the said National Control Committee's committees and activities.

Effective Date.

This Code shall be effective ten days after approval by the President of the United States and shall be applicable only to professional engineering services functional to the Construction Industry undertaken after such date.

Saving Provision.

If any court of competent jurisdiction shall finally determine that any Article or section of any Article in this Code, shall be invalid, all other Articles and sections of this Code shall nevertheless remain and continue in full force and effect in the same manner as though they had been separately presented for approval and approved by the President.

Engineers' Code Transmitted to NIRA

September 8, 1933

General Hugh S. Johnson
Administrator
National Industrial Recovery Administration
Commerce Building
Washington, D.C.

Re Code of Fair Practice for the Professional Engineer Division of the Construction Industry—1719/2/18

Dear Sir:

In accord with conferences with officials of the National Recovery Administration, and on behalf of the American Society of Civil Engineers, there is submitted with this supplementary letter the Code of Fair Practice for the Professional Engineer Division of the Construction Industry, in a somewhat revised form.

General Information. The American Society of Civil Engineers, organized in 1852, and being representative of the Engineering Profession in so far as it is functional to the Construction Industry, and being desirous to cooperate with the President of the United States to meet the present emergency as outlined in Title I of the National Industrial Recovery Act and to assist in placing the Construction Industry on a definite and permanent foundation of fair practices and fair profit, hereby submits and recommends for adoption a Code, with plan for administration thereof, governing professional engineers and their assistants and the practice of engineering where functional to the Construction Industry.

The American Society of Civil Engineers has been functioning for eighty-one years. It has fifty-six "Local Sections" with members in every state and territory of the United States. It is the major national professional engineering body in the United States embracing in its membership a large proportion of professional engineers functioning in the Construction Industry and is itself truly representative of the Engineering Profession in so far as it is functional to the Construction Industry.

In the preparation of this Code, however, it has been recognized that there are professional engineers affiliated with other national societies which, in general, are not functional to the Construction Industry and diligence has been exercised in bringing into cooperation in the drafting of this Code all such organizations of a national character which appeared to be interested, even if only in part, and also representatives of the professional bodies of registered or licensed engineers.

In the Code, provision is made for participation by all professional engineering bodies membership in which is contingent upon evidence of fair practice and qualifications of adequate training and actual experience in the execution of construction projects.

In the Code, provision is made also for the active participation by all professional engineers legally admitted to the practice of engineering, and through professional bodies, all engineers engaged in professional engineering in states where there are no such legal requirements.

The Code provides for fair charges which have been recognized as practicable for the protection of the public interest as set forth in a published document of the American Society of Civil Engineers to be appended to and incorporated in the Code. Twelve copies of "Manual of Engineering Practice; 'Charges for Engineering Services'" were placed on file with you at the time of the previous submission of the Code. In the Code, provision has been made, also, for fair standards of salaries or wages of professional engineers and engineering assistants.

Thus the American Society of Civil Engineers in sponsoring this Code believes that in doing so it has made provision for full recognition of the interests of all professional engineers and their engineering assistants functional to the Construction Industry.

Enclosures. Twelve mimeographed copies of Code of Fair Competition for the Professional Engineer Division of the Construction Industry, dated September 8, 1933, revised as for public hearing.

It is respectfully requested that date for such public hearing be fixed as early as practicable.

Very truly yours
Carlton S. Proctor
Chairman, Code Committee
American Society of Civil Engineers

(*Encls.*)

An Explanation of the Engineers' Code

A Statement Made by Carlton S. Proctor, M. Am. Soc. C.E., Chairman of the Code Committee, at the Time of the Presentation of the Code to the National Industrial Recovery Administration at Washington, D.C., on October 9, 1933

In presenting this Code of Fair Competition for Engineers, it seems desirable that certain statements and explanations be made. In this Code the endeavor has been to make such provision for self-regulation as is believed to be consistent with the spirit of the NIRA, and with the best interest of the profession. An effort has been made to correct conditions as they actually exist, not as it might be wished conditions were, or as many blindly contend they are.

It is recognized that the present economic depression has created undermining and destructive practices within the Engineering Profession. These must be corrected if the profession is to continue on the high plane of ethical standards which is essential to the public interest in the planning and installation of construction works.

Specifically, the present dearth of construction work and the consequent shutdown of all branches of engineering practice have caused some engineers in private practice to enter into price competition for engagement, with the inevitable result that in many cases the services properly to be performed by the engineer have been skimped and the salaries of the employed engineers and engineering assistants materially reduced to avoid actual loss. This practice has influenced the wage standard for the entire profession, and far too many employers have taken advantage of the situation to exploit the services of their employed engineers to their own profit.

Traced to its source, much of this practice may be charged against the Federal Government itself, where professional services have frequently been obtained, on many important governmental projects, on a comparative fee basis. This has forced fees to such a low point that inadequate and incompetent engineering services have resulted, with the only alternate to this an actual loss to the engineer. This fact makes the condition even more deplorable and makes the provisions incorporated in this Code more essential. The practice of price competition between engineers must be stopped, whether the agency fostering it be individual, corporate, or governmental.

Tied to the practice of shopping for engineers' minimum fee is the equally destructive practice of passing along the engineering responsibility for design, method of installation, and such, either by the under-paid engineer, in an effort to reduce his cost, or more frequently by the client himself, under the delusion that the costs of engineering services are thus saved and that such services are being provided free by the contractor or supplier of materials. Such practices frequently result in inappropriate designs to the harm of the client, and at the same time private engineering practice suffers immeasurably.

This Code of Fair Competition definitely prohibits price competition between engineers and the allocation by the engineer of any of his responsibility for design or supervision to the contractor or supplier of materials. The attempt has been made to clearly define the duties and functions of an engineer and to require that all who so function shall be considered engineers and subject to the conditions of this Code. At the same time the Code provides, reciprocally, that the engineer shall not perform, as an engineer, the definite functions of the other branches in the Construction Industry.

It is thoroughly understood that this Code cannot serve its purpose unless and until the standard of wages paid throughout the profession to professional and sub-professional employees is raised to a high standard consistent with the demands for the cultured living conditions requisite to professional standards. It is also thoroughly understood that the present standard of wages is in many cases below the actual requirements for mere living needs. Those thousands of men who have given their best years to arduous study and preparation, long hours of work in preliminary apprenticeship, and have dedicated their lives to the Engineering Profession, must receive adequate wage compensation and the security and continuity of employment to maintain a standard of living which will permit them to continue to call themselves "professional" men. It is the declared intention to utilize the offices of this Code for that purpose. A workable and practicable schedule of salaries and wages, now included in this Code, would be ideal, but an inequitable or unworkable schedule written into this Code would defeat its own objective. It has become obvious that standards of fair wages are so varied as between the multiple branches of engineering practice and in the many sections of the country, that the schedules desired and necessary to rehabilitate the profession can result only from a careful survey and study by regional or state committees covering the entire country and all branches of the profession. The Code stipulates, therefore, that such surveys and studies are to be immediately undertaken and that a schedule of wages shall be recommended to the President for his approval as an amendment to this Code within not more than four months after the effective date of the Code; and it is sincerely hoped that this work may be accomplished in half that time.

Similarly, if this Code is to be effective in eliminating fee competition for engineering services and in requiring the selection of engineering services based on reputation, experience, organization, and specialized training, and on a basis which will permit engineers to provide complete services with maximum results in economy of design, minimum fees must be standardized. But here again there is a wide variation as between the multiple branches of engineering practice throughout the various sections of the country, coupled with the essential requirement that, as in all other branches of the Construction Industry, prices must be maintained within such limits as to encourage rather than discourage new construction. Therefore a considerable amount of work through regional and state committees must be done before a proper and equitable schedule of fees can be incorporated as an amendment to this Code; but provision for such an amendment is made in the Code.

Until such schedules of fair wages and of fair fees can be formulated, the only alternative has been to make reference to the best

existing code of fees extant and to refer to the maximum hours and minimum wages for engineers and engineering assistants in the very minimum terms prescribed by the act. Such wages as are therein prescribed as minimum are by no means those that are appropriate to even the conditions of the present time, but because it is necessary that some figures must be cited, and until a truly rational schedule of appropriate wages can be developed, those are the figures that have been inserted. It is thoroughly to be understood that the schedules to be prepared will be materially above those figures, which doubtless represent wages suitable for the completely unskilled laborer and by no means suitable for the trained engineer or his assistants.

In the development of this Code every effort has been made to assure the broadest possible cooperation with the engineering organizations throughout the country. Each national, and many regional and local organizations of engineers, which could be considered at all functional to the Construction Industry, were invited to send representatives to sit in on the development, discussion, and consideration of this Code. Each draft of the Code was sent by mail to every engineering organization invited to participate in these conferences, and the widest discussion, criticism, and suggestion was invited throughout the country. At the completion of each successive draft of the Code it was distributed to national and regional engineering organizations for their approval or criticism. Every criticism or suggestion made, received the most careful consideration, so that it is believed that greater cooperation and greater representation in the development of a code would have been impossible, and that this Code represents the desire and effort of the the strong majority of organized engineers functioning in the Construction Industry.

In conclusion may I say I believe the Engineering Profession welcomes this opportunity to join with the President and the NRA in this splendid effort toward the rehabilitation of American industry and the reestablishment of employment, and it is in this spirit that this Code is submitted for the President's approval.

Meeting of the Board of Direction—Secretary's Abstract

ON SEPTEMBER 25 and 26, 1933, the Board of Direction met at the Edgewater Beach Hotel, Chicago, Ill., for its regular meeting, as required by the Constitution; with President Alonzo J. Hammond in the chair; and present George T. Seabury, Secretary; and Messrs. Buck, Crocker, Dufour, Enger, Gregory, Henny, Herrmann, Holleran, Horner, Jonah, Lupfer, Mead, Mendenhall, Morse, Noyes, Perry, Reed, Riggs, Sanborn, Sherman, Stevens, Stuart, and Tuttle.

Approval of Minutes of Board

The minutes of the meetings of the Board held on June 25 and 26, 1933, were approved.

Approval of Minutes of Executive Committee

The minutes of the meetings of the Executive Committee held on June 26, 1933, and on August 25 and 26, 1933, were approved, and the actions outlined therein were adopted as the actions of the Board.

Milwaukee Section Asks Amendment to Constitution

Upon request of the Milwaukee Section, permission was granted to change its Constitution so that three months shall be the maximum period for arrearage in dues without forfeiting Section membership.

Power Division Sponsors Testimonial to Allievi

Sensible to the great achievement of Lorenzo Allievi, eminent Italian engineer in the field of hydraulics, particularly on the subject of water hammer, the Power Division proposes to join with the Hydraulics Division of the American Society of Mechanical Engineers in issuing a suitable memorial. The proposal received the approval of the Board. The testimonial will be signed by the presidents, secretaries, and the chairmen of the respective technical divisions of the two societies.

Conference on "Low-Cost Housing"

Invitation was received from the Cleveland Engineering Society for appointment of a representative at a National Conference on "Low-Cost Housing" in Cleveland, October 25–27, 1933, at which advances in design and construction and discussion of housing problems are to be treated. The Board authorized the President to accept the invitation and appoint a representative. Subsequently, W. W. DeBerard, M. Am. Soc. C.E., was named.

Engineers' Code of Fair Competition

By invitation, Carlton S. Proctor, M. Am. Soc. C.E., appointed by President Hammond to act as chairman in the drafting of a Code, addressed the Board, detailing the efforts and accomplishments of the Society's committee in formulating a Code of fair competition for engineers as a part of the larger program under the NRA covering the regulation of the construction industry. He explained in detail the origin and development of the Code in conjunction with similar documents on the part of the architects, general contractors, and others, expressing the conviction that the profession would be greatly benefited by the Code as it will be recommended to the NRA for approval and adoption. The Code as drafted (dated September 18, 1933) was approved by the Board.

New Members on Division Executive Committees

The Board appoints each year a new member on the executive committee of each of the Technical Divisions, such member to serve for five years. Based on recommendations from the nominating committees of the Divisions, the following Corporate Members were appointed on the executive committees of their respective Divisions:

Division	*Nominee*
City Planning	Harold M. Lewis
Construction	H. W. Hudson
Highway	George E. Hamlin
Sanitary Engineering	Charles W. Sherman
Structural	Almon H. Fuller
Surveying and Mapping	W. N. Brown
Waterways	W. H. McAlpine
Irrigation	Alfred Tamm

Authority to appoint new members for the Power and the Engineering-Economics and Finance Divisions was delegated to the Executive Committee of the Board.

Questions of Professional Conduct

Report was received from the Committee on Professional Conduct covering six matters. The committee submitted a detailed report of the questions involved in the acceptance by engineers in public service of outside engagements. This report is given in full elsewhere in these pages. In accordance with the recommendation of the committee, the Board adopted by majority vote an additional item to be incorporated in the Code of Ethics, whereby it is considered unprofessional and inconsistent with honorable and dignified bearing for any member of the American Society of Civil Engineers:

"7. To actively solicit private work in competitive fields, when engaged in full-time teaching or employment in public service; or, when so engaged or employed, to accept any engagement for private work without exacting fees therefor at least as large as would be charged by competent engineers in private practice; or to maintain a permanent office for private practice without the express approval of his employer."

Election to Honorary Membership

Ballots for Honorary Membership were canvassed, resulting in the election of F. E. Turneaure, M. Am. Soc. C.E.

Financial Study of Society Publications

Responsive to request of the Board, the Committee on Publications submitted a report, showing the general cost of Society publications over the past few years. The report was accepted unanimously. A résumé will be found elsewhere in this issue.

No Changes in Districts and Zones

A report from the Committee on Districts and Zones was accepted, in which it recommended that no changes be made for the year 1934.

New Student Chapter

Accepting the recommendation of the Committee on Student Chapters, the Board approved formation of a Student Chapter at Tulane University, New Orleans, La.

Report of Special Committees

Routine reports of special committees to the Board were received and placed on file.

Prizes Awarded for 1933

Report of the Committee on Prizes for papers published in Volume 96 of TRANSACTIONS was received and approved. The list of prize winners and the papers for which the prizes are to be warded is given in full on another page of this issue.

Coordination of Joint Activities

The committee of five Board members, authorized at the June meeting, to study all features of the possibility of coordinating the various joint activities of the Founder Societies into one central agency, brought in a comprehensive plan of coordination, which was unanimously approved by the Board for submission to the other Founder Societies for their consideration.

American Engineering Council

In accordance with the recommendation of the committee which brought in the comprehensive plan of coordination of joint activities of the Founder Societies, the Board voted to remain in American Engineering Council for the present with the hope that the matter of a central administrative agency will be decided upon in the near future. Several topics proposed by American Engineering Council as to its procedures for the coming year were acted upon.

New Board Members Invited to Outgoing Board Meeting

In accordance with recent practice, authority was given to invite members of the incoming Board of Direction to attend the meeting of the retiring Board in January, the object being to familiarize new members with pending issues and Board procedure.

Coming Society Meetings

For 1934 it was deemed desirable to follow the practice dictated by economy for 1933, namely, to omit the Spring Meeting. A meeting place for the Convention in the summer of 1934 was determined upon by unanimous acceptance of the invitation from Vancouver, British Columbia.

Appreciation of Efforts in Public Works

Recognizing the vast amount of effort and time bestowed by John P. Hogan, M. Am. Soc. C.E., on the general subject of public works, as chairman of the Society's Committee on Public Works, resulting in constructive progress in several directions, the Board unanimously adopted a resolution of thanks and commendation. The testimonial in full is printed elsewhere in this issue.

Administrative Details

In addition to discussion of reports from standing committees, the Board gave detailed attention to various other administrative matters.

Adjournment

The Board adjourned to meet in New York, N.Y., January 15, 1934.

Honorary Member Elected

At the meeting of the Board of Direction held in Chicago on September 26 an eminent engineer, Frederick E. Turneaure, M. Am. Soc. C.E., Dean of the College of Mechanics and Engineering of the University of Wisconsin, was elected to Honorary Membership in the Society.

Dean Turneaure has spent his life as an educator of engineering students. His affiliation with the University of Wisconsin dates from 1892. He has given freely of his knowledge and energy to the technical work of the Society, his most recent contribution being the exhaustive research on steel columns on which he and his committee labored for a period of nearly ten years. The results of this research have just been printed in the 1933 TRANSACTIONS, *Vol. 98. One of the interesting features of the Annual Meeting in January will be the bestowal of this Honorary Membership upon Dean Turneaure.*

Resolution of Gratitude to John P. Hogan

AS MENTIONED in the Secretary's abstract of the minutes of the Board of Direction Meeting held at Chicago in September, the following resolution was passed on that occasion:

"WHEREAS, John P. Hogan, Member of the American Society of Civil Engineers, about February 1932 had the foresight to conceive the value of a great national public works program for our country as a partial relief for the millions of unemployed citizens and as a probable stimulus to trade recovery, and

"WHEREAS, Colonel Hogan had the courage of his convictions and the tenacity, ability, and persuasiveness to win for his ideas the support of many members of the Society, and

"WHEREAS, As a result the Board of Direction of the Society appointed Colonel Hogan as chairman of a special committee known as Committee on Public Works, and

"WHEREAS, Colonel Hogan was instrumental in bringing about the organization of the National Committee for Trade Recovery under the auspices of the Construction League of the United States, an agency to make effective the ideas approved by the Board of Direction, and

"WHEREAS, Colonel Hogan served from May 1, 1932, to July 1, 1933, as a member of the national executive committee of the National Committee for Trade Recovery, giving invaluable service to that organization, and

"WHEREAS, Colonel Hogan has spent literally months of his time unselfishly and without personal compensation in Washington engaged in the affairs of the Society's Committee on Public Works and the National Committee for Trade Recovery, and

"WHEREAS, It is commonly granted in informed circles in Washington that Colonel Hogan's work in conference with certain members of the United States Senate and members of the House of Representatives and in contact with high officials of both the Hoover and the Roosevelt administrations was in no small part influential in causing the Emergency Relief and Construction Act of 1932 to be passed in such form as to include Title II and again, as to cause the inclusion of Title II in the National Industrial Recovery Act of 1933, both of which make provision for a large program of public works, and

"WHEREAS, Colonel Hogan was selected with two other engineers by Gen. Hugh S. Johnson to set up the preliminary organization as a basis for the Public Works Administration now being administered by Secretary of the Interior Ickes, and

"WHEREAS, Colonel Hogan's efforts during both the Reconstruction Finance Corporation period and in the preliminary stages of the Public Works Administration were of greatest value to the Society and to the Nation, and

"WHEREAS, Since July 1933 Colonel Hogan has served as vice-chairman of the Code Committee of the Construction League of the United States in a long and intensively sustained volunteer effort to bring about an earnest coordination of the construction industry, now therefore be it

"*Resolved*, That the Board of Direction of the American Society of Civil Engineers at its meeting at the Edgewater Beach Hotel in Chicago, on Tuesday, September 26, 1933, desires to extend, officially, the thanks of the Board of Direction and the officers of the Society and through the Board of Direction the thanks of the entire membership of the Society to Col. John P. Hogan, Member, for his magnificent work during this past one and one-half years, both in connection with the creation and development of the great national public works program which is directly beneficial to members of the engineering profession, and for his splendid work as a member of the Code Committee of the Construction League in its remarkable effort to consolidate the Nation's many construction elements into a coordinated and cooperative construction industry; and be it further

"*Resolved*, That the Board of Direction is desirous of incorporating in its minutes and so orders, its gratitude to Colonel Hogan for his unusual and unselfish, courageous and splendid personal efforts and accomplishments, and that the Secretary of the Society be, and hereby is, instructed to transmit a copy of this resolution to Colonel Hogan in suitable form."

Official Nominees for 1934

THE SECOND BALLOT for Official Nominees for Vice-Presidents and Directors of the Society was canvassed at Headquarters on October 16, 1933. As announced in the October issue, the Nominating Committee, meeting in Chicago on September 25, chose Harrison P. Eddy as the Official Nominee for the next President of the Society. Therefore, on the next and final ballot the following names will appear as the Official Nominees for offices in 1934:

For President:

Harrison P. Eddy, of Boston, Mass.

For Vice-Presidents:

Zone I, John P. Hogan, of New York, N.Y.
Zone IV, H. D. Dewell, of San Francisco, Calif.

For Directors:

District 1, O. H. Ammann and C E. Trout, both of New York, N.Y. (two to be elected).
District 2, Frank A. Barbour, of Boston, Mass.
District 6, Thomas J. Wilkerson, of Beaver Falls, Pa.
District 10, Frederick H. McDonald, of Atlanta, Ga.
District 13, T. E. Stanton, Jr., of Sacramento, Calif.; and B. A. Etcheverry, of Berkeley, Calif. (one to be elected).

In the event of a tie vote, the names of both candidates must appear on the final ballot. On this second ballot a tie occurred in District 13, which accounts for the fact that two names will appear on the final ballot for Director in that District, although only one can be elected.

In accordance with constitutional requirements, space is provided on the final ballot, under the name of each official nominee, in which members may write in, or paste on, the name of any other candidate for whom they prefer to vote. Still another constitutional possibility is that of a "nomination by declaration" for any of the offices. Such a declaration, signed by at least 25 Corporate Members and accompanied by the acceptance of the nomination by the nominee, must be filed with the Secretary before November 25. The names of candidates nominated by declaration appear on the final ballot.

In conformity with the Constitution, the final ballot is mailed to all corporate members 40 days before the Annual Meeting and must be returned in time to reach the Secretary before 9 a.m. on January 10, one week before the first day of the Annual Meeting. The names of those receiving the highest vote on this ballot are announced at the Annual Meeting. These members are declared elected to the respective offices and at that time take up their new duties.

Some Reflections on Publications Costs

SLIGHTLY CONDENSED FROM THE REPORT OF THE COMMITTEE ON PUBLICATIONS TO THE BOARD

At the request of the Board of Direction, the Committee on Publications presented a report at the meeting of the Board held in Chicago on September 26, outlining recent data and trends in Society publications. Some of the more important features of the report, as approved by the Board, are given here in slightly condensed form. The full report was signed by the committee: Henry R. Buck, Chairman; John H. Gregory, Leslie G. Holleran, Edward P. Lupfer, and Henry J. Sherman.

ANY CONSIDERATION of Society publications *in toto* should recognize their relations to each other and their fundamental unity as an important activity of the organization as a whole. This ideal was definitely in the minds of Society officers when the latest important change in policy took place, namely, in 1930 with the institution of CIVIL ENGINEERING. Such an innovation was deemed desirable only because of its marked contribution to the welfare of the entire organization. As since administered, the two main divisions of publication effort, PROCEEDINGS and CIVIL ENGINEERING, have been handled with a single motive in mind—the greatest aggregate good in disseminating useful information to members of the Society.

In line with this ideal, a distinct division was set up whereby each publication served its particular purpose in the larger field without overlapping. PROCEEDINGS, the older, confined itself to strictly technical articles of a fundamental character, which were considered desirable for permanent record and upon which discussion and clarification seemed essential. The newer periodical, CIVIL ENGINEERING, catered to the more readable or picturesque field, with articles of rather easy understanding and more casual interest, together with official items of Society records, reviews of literature, and similar professional rather than technical interests. In keeping also with its more popular appeal, the important decision to include advertising was made.

Finances of such joint operation of publications were carefully considered in advance. While Society officers visualized a future which indicated possible great income from advertising, they did not delude themselves into believing that such a result was either an early expectation or indispensable to the future program. Instead, it was hoped only that at an early date the new plan would result in a net cost to the Society no greater than the previous cost of PROCEEDINGS alone. This hope has been more than fulfilled.

VARIATIONS OVER A SIX-YEAR PERIOD

Experience over the past three years has now given a moderate number of data whereby the success of the present program can be gaged. Unfortunately, CIVIL ENGINEERING has not had a sufficient history to prove its possibilities on a long-range scale. Instead, only two complete years and a fraction are available in full record. For comparison of the two programs, the Committee has studied its records for the past six years, which therefore include, starting in 1927, three complete years under the old system, one year under a combined system (CIVIL ENGINEERING was started in October 1930), and two full years under the present plan.

TABLE I. COST OF TECHNICAL PUBLICATIONS OF THE SOCIETY—FROM ANNUAL REPORTS

YEAR	PROC. (PART 1) AND TRANSACTIONS	PROC. (PART 2)	CIVIL ENGINEERING			TOTAL NET COST OF PUBLISHING
			Cost	Advertising Return	Net	
1927	$66,000	$3,600	.....	.....	.....	$69,600
1928	61,600	3,800	.....	.....	.....	65,400
1929	58,400	3,900	.....	.....	.....	62,300
1930	52,900	2,800	$ 9,000	$ 3,600	$ 5,400	61,100
1931	42,300		41,000	30,700	10,300	52,600
1932	37,300		32,800	22,800	10,000	47,300

TABLE II. VOLUME OF TECHNICAL PUBLICATIONS AND SOCIETY AFFAIRS FROM ANNUAL REPORTS

Thousands of Words Equivalent. Approximate Size Based on Detailed Count for 1929

YEAR	PROCEEDINGS	MANUALS	MEMOIRS	CIVIL ENGINEERING	TOTAL
1927	1,940	4	..	...	1,940
1928	2,090	..	..	...	2,090
1929	1,870	10	..	...	1,880
1930	1,590	151	30	220	1,990
1931	1,120	18	130	1,050	2,320
1932	1,080		130	1,010	2,220

As a general picture of this six-year period, cost figures from the Society's annual reports have been compiled in Table I, which shows the various budgetary items included in the expense of Society publications. No attempt has been made to allocate that part of Headquarters expense attributable to the various periods and volumes. It should be noted that during several years the actual outlay for PROCEEDINGS and TRANSACTIONS was considerably less than that shown, by the amount of contributions from outside sources on a cooperative basis. Grants from the Engineering Foundation, the Great Northern Railway, the late

John R. Freeman, Hon. M. Am. Soc. C.E., and the Port of New York Authority, have greatly assisted our declining budget. Without this help the Society could not have maintained such a creditable output of technical papers.

Even waiving these important financial considerations, the constantly decreasing total costs are rather remarkable. As will be noted, the resulting net normal expenditure during 1932 is only about 68 per cent of that in 1927.

To complete the picture, a record of technical output during this same period is given in Table II. This tabulation, likewise based on annual reports, is approximate for some of its figures, being computed on average results obtained from a rather careful study for one year. Comparatively, however, since the basis of computation is common for all years, the results should be significant.

Table III. Unit Gross Costs of Technical Publications—from Annual Reports

Year	Proceedings and Transactions		Civil Engineering	
	Total Pages Thousands	Cost per Thousand Pages	Total Pages Thousands	Cost per Thousand Pages
1927	80,688	$0.80	.....	....
1928	83,067	0.74	.....	....
1929	81,285	0.72	.....	....
1930	71,630	0.74	4,026	$2.23
1931	57,793	0.73	20,572	1.99
1932	60,680	0.61	16,786	1.95

Viewing these tabulations in parallel, it will be noted that during the entire period the publication expenditures decreased about 32 per cent, while the output increased about 15 per cent. Combining these two factors, it appears that $1.00 of Society expenditure in 1932 went as far as did $1.68 in 1927. By including the assistance of cooperative agencies, the actual return for the expenditure of Society money appears to be even more favorable.

As another yardstick of relative expenditures, Table III, also taken from annual reports, indicates the varying page costs for all Society publications during the years in question. In this study, Proceedings and Transactions are properly grouped together inasmuch as all the processes involved dovetail.

This page-cost basis is convenient for studying cost trends for a longer period, including years for which total figures but not detailed subdivisions are available. From such a longer study, also noted in annual reports of the Board of Direction, a remarkable fact is indicated—that since 1921, or in eleven years, the cost per thousand printed pages has been reduced by half, from $1.21 to $0.61. During that period while the volume of printed matter and the edition have fluctuated somewhat, the total change is minor so that the comparison is valid.

Many of the factors contributing to this successful showing can be isolated and identified. In part, they have been due to falling prices of materials and to better contracts for printing and engraving. Important savings, however, have been secured by internal improvements in policy as affecting, for example, the publication of Meeting programs, the handling of Society Memoirs, the economies in treating applications for membership, and the securing of second-class postal privileges.

While the Committee on Publications has been cognizant of these economies and has been consulted in advance on the more important ones, the savings should be largely credited to the Society's publication staff.

Civil Engineering as an Advertising Medium

At the time Civil Engineering was established, the greatest uncertainty in the future program concerned the amount of income from advertising. Today, based on the experience of almost three years, its future is more definite.

This is the only American publication that confines its editorial pages exclusively to the subjects of interest to civil engineers. It is the only periodical with its circulation concentrated exclusively upon members of the civil engineering profession. A group of substantial advertisers have come to rely upon it as a direct selling force in covering the leading members of the profession.

Civil Engineering has not as yet paid its way as a self-sustaining publication. Conditions have been adverse. When it was established in October 1930 advertising appropriations were even then being trimmed slightly. Nevertheless, 179 pages of advertising were secured in the first twelve months of publication, in comparison to the preliminary budget of 159 pages that was anticipated for this period.

Notwithstanding the greater shrinkage which has since occurred in all fields of advertising, our three years of operation show that the advertising secured has paid for all costs of operation of the advertising department, and has contributed substantially toward the remaining costs of the publication.

It is conservative to state that Civil Engineering has become definitely established as an effective advertising force in the minds of a substantial number of leading advertisers and advertising agencies. When general conditions improve, Civil Engineering should carry a substantial volume of advertising from many leading organizations which are not now among its advertisers.

When such increased revenues eventuate, it is the firm conviction of the Committee on Publications that they should be expended on publications or placed in the Society's permanent funds; they should not be used to defray running expenses or anything approaching thereto.

No record of the costs themselves would be complete without an evaluation of the benefits derived from such expenditures. The outlay for publications is the largest single item in Society activity. The Committee on Publications believes that such outlay is justified by the benefits derived. To many members, such publications constitute the major return, if not the sole return, from Society affiliation. In November 1926, a questionnaire was addressed to 1,000 new members of the Society, inquiring as to their reasons for joining. The value of publications outvoted all others and was particularly emphasized by the Juniors.

The present set-up of our publications constitutes an ideal arrangement. In Proceedings the Society has its fundamental technical organ, with a long and illustrious professional history and a reputation not excelled throughout the world. Matter extraneous to its strictly technical field has now been removed from this publication so that the high quality of its contents is undiluted. It provides not only for publication but for extensive discussion of quality material. This distinguishing feature sets it in a class by itself not approached by other engineering media; it makes possible the eventual publication of Transactions with the author's closure, presenting in one place all views on an important technical question—a unique feature. The Committee on Publications therefore voices the general sentiment of members in expressing its high regard for this publication as primary and indispensable to technical advance in the profession.

Civil Engineering, on the other hand, has met with wide approbation as giving in lighter, more readable form articles of technical or professional interest to civil engineers. Although its format is quite flexible, it has not been adjusted to take either long articles or highly theoretical articles.

Perhaps no Society activity in recent years has exicted the interest and favorable response that have been accorded to Civil Engineering. Many letters and personal recommendations have been received by the Committee and by the editorial department. The articles themselves have been widely copied and reprinted. Other publications have adopted the method and format of Civil Engineering. Articles and discussions have been received from far and wide, including many from abroad.

Through the availability of both publications, the Committee believes that the Society is favored with a most fortunate set-up. Within its financial limitations, it has been able to do justice to every paper of reasonable civil engineering content by allocation to one or the other of these media. The two are therefore supplementary and not independent.

To maintain a reasonable quantity and a balanced content for our publications in these days of lessened Society income and correspondingly reduced budget is indeed a trying task. From its point of vantage the Committee on Publications has viewed the struggle with considerable concern but eventually with much satisfaction. This fortunate outcome whereby our technical output has suffered relatively little has not been attained without much study and constructive effort. It is a pleasure to acknowledge the whole-hearted cooperation of officers, members, assisting organizations, authors, advertisers, printers, and staff. None has failed in the emergency. To the Committee on Publications it has seemed that the objective has well warranted the sacrifices entailed. We may all look forward to the future of this essential Society effort with pride and confidence.

J. Waldo Smith, 1861–1933

BY THE DEATH, on October 14th, of Jonas Waldo Smith, Honorary Member of the Society, the profession has lost one of its ablest leaders and counselors. Only history will be able to appraise his true greatness. Those of us whose privilege it was to know him intimately were too near to see him in true perspective. The record of his accomplishments is as an open book which, when compiled for the archives of the Society, will recite them in detail, but no such recital can fittingly describe the attributes that distinguished the man.

J. WALDO SMITH, 1861–1933

Exactly as he was a leader in technical progress and in the encouragement of investigation and research, so also was he a leader of men. He led by the inspiration of example, by concern for the welfare of the individual, and by personal counsel and advice. Only those who were associated with him on the Catskill Aqueduct, of which he was Chief Engineer, will ever be able to know and to appraise his inborn qualities to the full.

He was a man of quiet yet dynamic force, always looking to the future and anticipating the consequences of every decision and the results of every construction. His entire life was based on fairness, on justice, and on honesty. Nothing could win his approval except merit, and his every conclusion measured and weighed all of the equities. These qualities brought to him the respect and the love of his men, as well as the confidence and the admiration of all with whom he came in contact. So it was that mayors, public officials, and men of affairs not only relied on his advice but were his close friends and personal admirers.

In 1922, on the occasion of Mr. Smith's retirement from the post of Chief Engineer of the Board of Water Supply of New York City, former Mayor George B. McClellan, at a great dinner said among other things:

"Immediately after I became Mayor I met the Chief Engineer of the Croton Aqueduct Commission as Smith then was, and found that in developing the new Catskill Water Supply project he was just the man I needed. We soon learned to understand each other and to work together, so that ever since the Catskill project has been for me nothing but the concrete expression of the personality and of the genius of Waldo Smith.

"When a reluctant legislature had given us our needed legislation and when the commission had taken office, as a matter of course Waldo Smith was appointed Chief Engineer. And such he has remained until today, increasing always in the respect of his subordinates, in the affection of his friends, and in the confidence of the public.

"Smith's outfit was as fine a lot as I have ever known. Its corps spirit, its spirit of cooperation and solidarity, its spirit of mutual reliance and mutual help, was ideal. Its condition was that which, according to army regulations, ought to exist in every command and unfortunately seldom does. In the old days headquarters at Ashokan was like a great happy family which was united under its head in one great purpose in the accomplishment of which every man was unselfishly willing to sink his ambition and himself for the triumph of the cause he had at heart.

"Waldo Smith, you and I have known each other for a long time. We have fought the good fight together side by side for many a year. We have known foul weather, and we have known pleasant days. We who once were young but now are old can look back across the years and find that Time has drawn his kindly veil over the past so that the unpleasant things have been forgotten and only the pleasant things remain. Sometimes in the long ago the outlook seemed very dark, but that we have ceased to think of 'For we when young did seek romance, but never knew it till its day was done.' We know it now and can rejoice always that we have had our share in the unfolding of a fairy tale.

"And such a fairy tale as it has been! Rivers turned backward from the sea, and made to flow through caverns in the hills, towns moved bodily from valleys to the heights, forests transmuted into lakes and a great sea called into being where hills and valleys used to be. Overnight an almost desolate countryside made populous with thousands of the magician's men summoned from distant lands to work his will. And overnight again the surface of the earth is changed and mountains disappear, and woodlands vanish, and water is where dry land was, and once again man has triumphed over nature.

"And you are the magician who has done these things. You have waved your wand and by its magic you have made it possible for six million people to live in this city of ours, where three million were before.

"Long after all of us here tonight have gone and been forgotten and our very names have passed from human ken, the work which you have wrought bravely and honestly and well, will endure, serving the people of the New York we love.

"Greater honor can no man have than that which is yours—to serve New York in great achievement.

"Greater reward can no man have than that which is yours—the consciousness of having by your genius helped to make our city a happier place to live in, and of having helped to make the world a little better than you found it."

Such was the man and so was he honored in life even as we now honor him in memory. He was a genius of skill and prophetic vision. His leadership was that of fearless honesty. He held his profession as a cause to be kept sacred and to be made the better. To this end he accomplished far more than falls to the lot of most. As his name is written high on the record of achievement so also is it inscribed at the top of the scroll of those who have labored to promote the welfare of the engineer and the ideals of his profession.

Waldo Smith was a man of gentleness, and the modesty of greatness was his. He shunned publicity. As honors came to him he insisted that they were the due of his associates. He was kind and considerate always, but forceful, direct, and righteously indignant whenever occasion required. He loved the simple things of life. In his friends, his flowers, his pigeons, his dog, and in music he found peace and inspiration and comfort. The autumn of each passing year brought to him rare delight in the delicate blue of the fringed gentian, and now, in another autumn, he sleeps under the sod of Massachusetts where in boyhood he learned to live the truth and where the gentians, as herald of season's end, will bloom in all the years to come.

His friends cherish his memory. His influence will live through the years. A great man has gone from our midst and we are left with our eyes raised to the infinity of the heavens in the strength of the faith that is in us.

THADDEUS MERRIMAN, M. Am. Soc. C.E.

Additional Student Prize Winners Are Announced

WINNERS OF the student prizes awarded by Local Sections at commencement time were listed in the October issue of CIVIL ENGINEERING. Since the publication of that list three additional names have been reported to Headquarters. With the approval of the Board of Direction, the recipients of these prizes are permitted to join the Society as Juniors, their dues for the first year being paid by the Local Section that gives the award. The following names should be added to the list already published:

NAME OF STUDENT	INSTITUTION	LOCAL SECTION GIVING AWARD
Leonard Capling	Duke University	North Carolina
Dayton J. Lanier	University of North Carolina	North Carolina
John Wakefield Clingerman	Carnegie Institute of Technology	Pittsburgh

The Ethics of Salaried Engineers Engaging in Private Practice

Report of Board of Direction's Committee on Professional Conduct

The Committee on Professional Conduct has given careful consideration to the subject of professional practice by teachers in colleges and universities, which offer courses in engineering, and by officials or employees of government or private corporations. The subject was formally brought before the Board of Direction by the Cleveland Section in 1932, and by resolutions of the Buffalo Section in January 1933. In February 1933, your Committee requested the Secretary to forward copies of these communications to all Sections of the Society with request for comments.

The resolutions of the Cleveland Section were directed to three groups of salaried engineers and called attention to the fact that in a considerable number of cases outside practice was engaged in by members of these groups to the serious detriment of practicing engineers. These groups were: (1) professors and assistants in engineering schools; (2) salaried employees employed in public service, Federal, state, county, or municipal; and (3) salaried employees of private or quasi-public corporations, such as industrial corporations, railroads, or utilities.

Reports Received from Many Universities

In response to the request of the Secretary, replies were received from the San Francisco, Los Angeles, Seattle, San Diego, St. Louis, and Philadelphia Sections, all of them urging that such practice be placed under reasonable restrictions. Your Committee further asked the Secretary to request information from the leading engineering schools as to what, if any, restrictions were placed on their teachers and as to the extent and character of their outside practice.

It believes that while probably there have been occasional cases of professional practice on the part of college teachers and other salaried engineers that were decidedly objectionable, and some that could fairly be classed as unethical, this has been by no means general; and that the great majority of such outside practice has been free from criticism and has been to the advantage of the profession at large as well as to the engineers engaging in it and to the engineering colleges. Replies from officials of 77 colleges and universities indicate that there has been only a limited amount of outside practice; that is, a very few of the large number of engineering teachers engage in such practice, and the majority of those so taking outside work do so only occasionally and under conditions that are not objectionable. There is no uniformity of regulation of outside work by the colleges.

The profession of engineering is benefited by the good work of the colleges in training young men in the fundamental subjects which form the basis of sound engineering work and instilling in them the highest professional and ethical ideals. The colleges must have the most whole-hearted support of the profession if their graduates are to be placed and assisted to rise to positions of responsibility. Engineering students are quick to recognize sound professional teaching by men who have had practical experience in their special field. The colleges must draft able men from the profession to serve as teachers and must have many men on the staff who command the highest respect of practicing engineers because they are good engineers as well as good teachers. The president of one prominent school of applied science says:

> "We believe that teaching alone is not enough to build up the engineering teacher's professional competency. We also believe that teaching gains in authority when the teacher's competency is actually demonstrated from time to time in the realm of responsible performance. We are inclined, therefore, to give equal encouragement to research, to professional practice of an original character, and to service to the major organizations of the profession and to public bodies."

Many other answers to our inquiry are to the same effect. The consensus of opinion of university officials appears to be that a moderate amount of properly conducted outside consulting practice on the part of the older men, and of vacation work with engineering firms or industrial plants on the part of instructors is a helpful thing for an engineering and scientific staff. Where the service of university teachers is sought because of their specialized knowledge and experience and where it is supplementary to the work of other engineers, such practice is in no way unfair to engineers in private practice.

Your Committee believes that within reasonable and proper limits consulting practice on the part of engineering teachers should be encouraged not only by the colleges but by the profession, and that only such restrictions should be placed on such practice as will tend to prevent the objectionable and competitive practice which injures independent engineers who depend on the profession for a living.

It is very generally true that salaries in engineering colleges are not large and are not comparable with the incomes that are received by the leaders in consulting work or in the service of industry. The profession at large should give every encouragement to the colleges in trying to secure a salary scale that will ensure a comfortable living such as to do away with any necessity for taking outside work purely for the additional income. The college teacher should not engage in ordinary routine work primarily to increase his own income without benefiting the institution which he serves. With his salary to ensure his living expenses such a practice is unfair to outside practitioners. The outside work of the university man should be such consulting and expert work as will not interfere with teaching and other university duties and which is of such a type as to promise a very definite advantage of a professional kind to the man himself by increasing his value as a teacher and investigator.

The university teacher should avoid taking work which will bring him into direct competition with outside individuals or firms. He should keep himself in such a position that he is available as a consultant to any such practitioners, or to the state or any other public agency.

Governmental Employees with Specialized Knowledge

There are undoubtedly many instances in which an employee of some governmental subdivision or of some corporation may properly be called upon for outside consulting practice on account of his specialized knowledge. Such an engagement is no more objectionable or unethical than is the employment of the university professor. When an engineer has sought for a public position and accepted the salary connected with it knowing that the incumbent is expected to devote his full time to it, your committee does not believe it proper for him to take on outside work except under such restrictions as are here recommended.

Certainly where outside practice is engaged in by such employees of the public it should be done under restrictions similar to those suggested for university men. Their service is primarily due to the public, and no work which interferes with the rendering of maximum service to the government should be undertaken. All such outside services should be charged for at rates not less than those charged by the outside practicing engineers. There should be no use of office space, instruments, supplies, or material belonging to the unit of government employing them that would give the public official an advantage over the private engineer.

Your Committee is of the opinion that men employed by quasi-public or manufacturing corporations are so fully occupied by the work of their corporation and are working under such rigid restrictions that there can be but little complaint from this source of competition. Unquestionably it is proper for engineers of such corporations to take part in matters of public interest in their community whether compensated by the community or the company they serve. The Committee has no evidence before it of any general solicitation of engineering practice by this class of salaried engineers.

Restrictions on Practice

It would be very helpful if every college of engineering would adopt formal regulations governing the matter of outside practice of members of its staff. No uniform set of rules can be made which will fully meet all conditions that may arise. In the case of the majority of faculty members their high sense of duty to the college, of fair play to the profession, and of ethical responsibility is such that formal restrictions may be unnecessary.

Your Committee believes that reasonable restrictions on the

outside practice of salaried engineers would cover the following points:

1. All outside practice should be reported to, or have the advance approval of, the proper university or public authority.

2. No outside engagement should be accepted that does not tend to increase the value of the salaried engineer to the institution or public body which employs him.

3. Engineers on full-time salary should not actively solicit professional engagements in strongly competitive fields of work in which competent individuals or firms are engaged. It is especially desirable that the consulting practice of a college teacher should come to him without solicitation and because of his particular knowledge in some special field of engineering.

4. No engagement should be accepted which will

a) Detract from the ability of the individual to render complete and loyal service to his employer.

b) Embarrass or involve the institution or employer in unwholesome controversy.

c) Subject other professional engineers to unfair competition.

5. The maintenance of a permanent office for outside practice, and of a permanent staff engaged wholly on such outside practice is generaly an indication of a practice so active and extensive as to require solicitation and to demand an amount of attention which will detract from the value of his regular work. No such office should be maintained without full approval of the proper university or public authority.

6. No engagements should be accepted without exacting fees at least as large as would be required by competent professional engineers.

7. No free services should be rendered by a salaried engineer on strictly professional work for any client that would otherwise be assigned to a professional engineer and paid for.

8. Laboratory facilities of the college are provided for purposes of teaching and research and should be used by the university teacher only in his outside practice upon investigations incident to commissions which are consistent with the provisions of this report, and in such a manner as to give him no unfair advantage over the private engineer who is compelled to depend on the commercial laboratories. The taking of laboratory work of a purely routine and commercial type in competition with commercial laboratories is improper private practice for a college teacher.

All of the foregoing discussion applies to salaried engineers on full time. There are a number of cases in which practitioners of very high standing have been called to chairs in universities which were unable to pay a salary equal to the income derived from practice and where the appointment was made with the express understanding that the engineer would have the privilege of maintaining his office. Such cases do not fall within any set of regulations that might be designed for men who are primarily teachers and who are employed by the college on a full-time basis.

There are a number of teachers and public officials who are regular practitioners engaged on a part-time basis only and who depend for a living primarily or largely on income from outside practice. All such cases should properly be classified as practicing engineers giving part-time work to the college or to public service, and all of the men in these two groups would be guided by the ethical rules that would govern engineers in private practice.

RECOMMENDATIONS

Your Committee is of the opinion that this whole subject of the relations of salaried engineers to general practitioners can be covered by suitable inclusion in the Code of Ethics appearing on page 4 of the *Year Book*. To those activities listed in the Code which are "considered unprofessional and inconsistent with honorable and dignified bearing for any member of the American Society of Civil Engineers," it suggests adding a seventh paragraph as follows:

"7. To actively solicit private work in competitive fields, when engaged in full-time teaching or employment in public service; or, when so engaged or employed, to accept any engagement for private work without exacting fees therefor at least as large as would be charged by competent engineers in private practice; or to maintain a permanent office for private practice without the express approval of his employer."

HENRY E. RIGGS, *Chairman*
J. P. H. PERRY   JAMES F. SANBORN
RALPH J. REED   J. C. STEVENS

Engineers' Council for Professional Development Meets

First Official Session Adopts Program of Future Activity

WHAT literature is available for the guidance of young men who are curious about the requisites for a successful career in engineering? Are there any standards by which to judge the acceptability of engineering schools? Once graduated from a formal engineering course, has the young man any guide or mentor to encourage his efforts in continuing his studies, trying out his own powers of application, and proving himself fit to receive responsibility in his chosen profession? Is there any reasonably well-defined point in his career when he may be said in fact to have become an engineer?

There is scarcely an engineer in any branch of the profession who has not, at some time or other, sought the answer to one or more of these questions, either for himself or for someone else. Individuals, committees, whole societies, have labored on the answers and on related questions. At last a joint effort has been made by seven national societies. On October 10, the first annual meeting of the Engineers' Council for Professional Development was held in New York, as announced in these columns last month, and committees on each of these questions presented progress reports on the work done during the past year.

STUDENT SELECTION AND GUIDANCE

An analysis of the existing guidance literature is now occupying the close attention of the Committee on Student Selection and Guidance. After consultation with the National Occupational Council and other groups, it has formulated a program of study, concentrating on the proper objectives of such booklets as well as their contents. The committee intends to examine critically and to recommend, if satisfactory, sources of information for promising or interested high-school students, their parents, teachers, and counsellors. If satisfactory material is not available, the committee will consider its preparation, either by revision or by compilation. The committee has been instructed to proceed with its studies.

ENGINEERING SCHOOLS

The Committee on Engineering Schools is concerned with the extremely difficult subject of coordinating the efforts of several agencies to establish proper specifications for accrediting engineering schools. Laws governing the licensing or registration of engineers in a majority of the states require some method of accrediting such schools. To ensure that this is done uniformly, so as to be consistent with the high ideals of the engineering profession and a stimulus to the best development of engineering education rather than a deterrent to future progress through codification of certain present standards, the national engineering societies should be invited to prepare and administer a plan of accrediting engineering schools. Certain principles are already recognized, and the committee accordingly offered definite recommendations, to be transmitted to the constituent bodies of this council, that a program of accrediting be undertaken and that certain basic principles be adopted as a guide to such action. The council voted to transmit these recommendations to the constituent bodies regarding action.

PROFESSIONAL DEVELOPMENT

The Committee on Professional Development is concerned principally with the period in the young engineer's career when he

is performing the duties and studies of a novitiate in the profession. He may have received his bachelor's degree, or he may have been preparing himself for the profession without benefit of formal schooling. Such men are usually junior members in the several societies, or eligible for that grade of membership. What helpful contacts may be maintained with them during this period of practical experience and further intellectual development, until that time comes when they stand beside their fellows, fully recognized as professional engineers? The committee has taken for its objective the preparation of a program which will combine the early experience of the young graduate engineer with a plan of study and further development until he is qualified for full professional status. Such a period, more often than not characterized by groping in the dark, should have more beacons for guidance and a clearer concept of ways to avoid inefficiency, inertia, and possible discouragement. This committee has been instructed to proceed with its plans for studying the possibilities of the situation.

Professional Recognition

In the charter of the council the Committee on Professional Recognition is instructed to "report to Council methods whereby those engineers who have met suitable standards may receive corresponding professional recognition." Needless to say, the work of the other three committees leads ultimately to the accomplishment of this objective. The committee requested approval of a policy which may be briefed as follows:

As the goal of attainment, the profession should establish a series of qualifications for which the young man, whether graduate or non-graduate, may successfully and continuously strive from the time he enters upon an engineering career. This goal of attainment, embodied in a certificate equivalent to the professional degree, and having a value recognizable as adequate to entitle the holder to licensing or registration in a state, should be based on certain definite features.

Space does not permit the listing of these features at this time, but it may be said that they show the interlocking, and in some cases duplication, of many existing requirements for registration or licensing in a state, admittance to corporate membership in a professional society and, perhaps to a less evident extent, completion of the requirements for the professional degree (such as C.E., M.E., E.C.). A "Minimum Definition of an Engineer" is recommended, corresponding to that printed in the Model Registration Law, approved by a number of engineering organizations, including the Society. Likewise a codification of grades of membership is recommended. This committee's recommendations were approved for transmittal to the various participating bodies.

Representatives and Officers

The representatives of the Society are J. Vipond Davies and Harrison P. Eddy, Members Am. Soc. C.E., and C. F. Loweth, Past-President Am. Soc. C.E. The officers of the Engineers' Council for Professional Development are C. F. Hirshfeld, Chairman, C. E. Davies, Secretary, and the following members of the Executive Committee, representing the organizations indicated: J. Vipond Davies, American Society of Civil Engineers; Donald S. Irvin, American Institute of Mining and Metallurgical Engineers; William E. Wickenden, American Society of Mechanical Engineers; Charles F. Scott, American Institute of Electrical Engineers; R. I. Rees, Society for the Promotion of Engineering Education; H. C. Parmalee, American Institute of Chemical Engineers; and D. B. Steinman, M. Am. Soc. C.E., National Council of State Boards of Engineering Examiners.

It is scarcely necessary to say that great interest will attach to the action of the various societies on these recommendations. This council provides a medium for joint action on problems that have been sometimes embarrassing, generally defiant of simple solution, and always of interest to those who are thinking of the continued development of high standards for engineers.

Minutes of Society Meeting, October 18, 1933

In accordance with the requirements of the By-Laws, a meeting of the Society was held in advance of the meeting of the Metropolitan Section, Vice-President Arthur S. Tuttle presiding, and C. E. Beam acting as secretary.

The results of the report of the tellers on the canvass of the Second Ballot for Official Nominees were presented.

A brief moment of silence was observed out of respect to the late J. Waldo Smith, Hon. M. Am. Soc. C.E., who died on October 14, 1933.

There being no new business to be presented, the meeting was adjourned.

Society Badges for Christmas Presents

It is not too early to be reminded that the holiday season is coming and that Society badges make excellent Christmas presents for those who are entitled to wear them. This suggestion is made in confidence to the ladies whose men are members of the Society.

Pins have safety catches that sometimes fail to function as such. They often are damaged, perhaps by the laundry, or become misplaced. Many strange tales might be told of how lost pins have, after months or even years, been restored to their proper owner, by means of the identification engraved on the back.

Members are not entitled to have two badges, so if this Christmas gift is to replace one that has been lost, the member must file a statement to that effect at Society Headquarters. A form for this statement will be gladly furnished upon request.

Since the cost of these badges is but $5, they make inexpensive as well as useful gifts. It takes approximately two weeks to have the emblem, which may be obtained either in pin or watch-fob style, properly engraved with the member's name and grade. Orders should therefore be received soon after December 1, so that neither the giver nor the recipient will be disappointed at Christmas time. An engineer who is entitled to wear the Society's badge could receive no more appropriate gift.

Society Prizes and Awards for 1933

At its September meeting the Board of Direction approved the choices of the Committee on Prizes, and the following list of papers in Transactions was announced for the current year:

Norman Medal—To Hardy Cross, M. Am. Soc. C.E., for his paper, "Analysis of Continuous Frames by Distributing Fixed-End Moments."

J. James R. Croes Medal—To Earl I. Brown, M. Am. Soc. C.E., for his paper, "Flow of Water in Tidal Canals."

Thomas Fitch Rowland Prize—To the late J. C. Baxter, M. Am. Soc. C.E., for Part III of the paper on the eight-mile Cascade Tunnel, Great Northern Railway, "Construction Plans and Methods."

James Laurie Prize—To W. B. Saunders, M. Am. Soc. C.E., for his paper, "Construction of La Ola Pipe Line."

Arthur M. Wellington Prize—To D. J. Kerr, M. Am. Soc. C.E. for Part I of the paper on the Cascade Tunnel, "Preliminary Studies and Results of Improving Cascade Crossing."

Collingwood Prize for Juniors—To Bernard L. Weiner, Assoc. M. Am. Soc. C.E., for his paper, "Design of a Reinforced Concrete Skew Arch."

These papers are all to be found in the 1932 Transactions, Vol. 96. Actual presentation of the awards will be a feature of the Annual Meeting in January.

John Fritz Gold Medal for 1934 Awarded to John Ripley Freeman

At the regular annual meeting of the John Fritz Medal Board of Award, on October 20, 1933, its gold medal was awarded to the late John Ripley Freeman, Honorary Member and Past-President of the Society. The award was made posthumously because of Mr. Freeman's sudden death on October 6, 1932, during the procedure for his selection as a medalist. The medal was awarded to Mr. Freeman as "Engineer—preeminent in the fields of hydraulics and water supply, fire insurance economics, and analysis of earthquake effects."

A Preview of Proceedings

Because of a crowded issue the publication of the paper entitled "Some Soil Pressure Tests," by H. de B. Parsons, M. Am. Soc. C.E., previously announced to appear in the October issue of PROCEEDINGS, *has been postponed until the November issue. Also in this issue will appear a valuable paper on the technic of fluvial experimentation. As a result of recent model researches at the Vicksburg Hydraulic Laboratory, the age-old theory that cutoffs in the Mississippi River must be prevented has been challenged. This is but one of the many valuable results of laboratory experimentation on river flow. Both highway and bridge engineers will find much valuable material in the forthcoming paper on the 12-mile superhighway across the Hackensack Meadows of New Jersey, recently completed at a cost of 40 million dollars. For sanitary engineers especially, the paper on the use of ferric coagulants for the formation of floc, now ready for publication, will prove an important source of recent information on this subject. The natural cycle of rainfall, erosion, silt carrying, and delta formation is interrupted by engineering works. A paper in preparation for the November issue of* PROCEEDINGS *deals with the interrelation of these factors.*

Practical Laboratory Hydraulics for the River and Harbor Engineer

IN "Practical Laboratory Hydraulics for the River and Harbor Engineer" by Herbert D. Vogel, Assoc. M. Am. Soc. C.E., a brief practical exposition of the principles of hydraulic similitude is given. Presented originally to the University of Michigan, in partial fulfillment of the requirements for the civil engineeing degree, the paper constitutes a handbook of information that any laboratory technician will need in undertaking fluvial experiments. Beginning with a purely theoretical presentation, the author continues with some helpful examples, and ends with a practical discussion and description of the equipment necessary in establishing a laboratory such as that at Vicksburg, Miss. Typical experiments encountered in a river and harbor hydraulic laboratory are classified under two main headings, with three subheadings each, and problems incident to the study of fixed-and movable-bed models are described. A list of 26 problems that are susceptible to laboratory treatment also forms a part of this important work.

Lincoln Highway from Jersey City to Elizabeth, N.J.

IN A paper entitled "Highways as Elements of Transportation," which was published in Vol. 95 of TRANSACTIONS, Fred Lavis, M. Am. Soc. C.E., treated extensively the various political, physical, and economic considerations that led to the final location of Route 25 in New Jersey, now also known as the eastern end of the transcontinental Lincoln Highway. A paper by Sigvald Johannesson, M. Am. Soc. C.E., giving the construction details of this noteworthy engineering work, is now ready for PROCEEDINGS. The section described leads from the west end of the Holland Tunnel through Jersey City, Kearny, Newark, and Elizabeth to connect with the main highways of Trenton, Philadephia, and beyond. Begun in 1924, it was completed eight years afterwards and was opened for traffic on November 24, 1932. The total length is 12 miles, and the cost of construction was about $40,000,000.

BUILDING THE LINCOLN HIGHWAY IN NEW JERSEY
Piers for Passaic River Crossing Under Construction

THROUGH TRUSSES FOR HACKENSACK RIVER CROSSING
Identical with Bridge Over Passaic River

A very complete general description of the problems of alignment and grade, as well as of design is given by Mr. Johannesson. Of particular interest to highway engineers and designers will be the part devoted to a discussion of connections with cross traffic by means of ramps. In addition to ordinary structures, the project involved the necessity for steel-bridge river crossings, long viaduct structures, and a subway. The paper contains an adequate description of the construction problems entailed in driving pile foundations (both timber and concrete, and both precast piles and piles cast in place), expansion joints, roadway surfaces, curves, sidewalks, railings, and drainage.

Modifying the Physiographical Balance by Conservation Measures

THERE IS a balance between the processes of nature that controls erosion and debris transportation and deposition by stream flow. If this balance is regulated by man or is interfered with by conservation work, it may become so modified as to be a menace to exiting or future development. This is the theme of a paper, "Modifying the Physiographical Balance by Conservation Measures," by A. L. Sonderegger, M. Am. Soc. C.E., scheduled for the November issue of PROCEEDINGS. The paper contains a complete description of this physiographical balance and a discussion of many of the effects of interfering with it. In a general discussion, the author describes the effect of changes in the nature of the cover over a watershed. The effects of a regulation of stream flow is another aspect of the general subject, the effect of regulating the flow of the Rio Grande being given to demonstrate this theoretical reasoning. The paper includes, furthermore, a theoretical discussion of the effect on physiographical balance of erecting debris barriers. It ends with a complete statement of conclusions on the following subjects: (1) physiographical balance; (2) the physiographical interrelation of mountain, watershed, and flood menace; (3) the cooperation of governmental agencies necessary to the attainment of maximum yield of watersheds; (4) the possible flood menace produced by storage regulation; (5) the effectiveness of debris barriers; (6) the inadvisability of erecting temporary structures to check debris; and (7) the essential nature of water-table control in surcharging ground-water basins.

Formation of Floc by Means of Ferric Coagulants

IN RECOMMENDING the paper, "Formation of Floc by Means of Ferric Coagulants," by Edward Bartow, M. Am. Soc. C.E., A. B. Black and Walter E. Sanbury, for publication, one member of the Society calls attention to the fact that modern water purification is becoming more and more to depend on coagulation for its success. Satisfactory coagulation involves meticulous attention to very small changes in the character and condition of the raw water. In this paper are given the results of thorough and ex-

haustive research into the baffling problem of colloids, showing why certain coagulants are successful with certain waters and not with others, or even with the same water under changed conditions. This is a notable advance in practical knowledge. Heretofore the operator of each filter plant has struggled with his own special conditions until he found a formula that would reduce complaints from consumers and not cost too much. If his formula were tried with a different water, it was useless.

The work described in this paper was conducted as a continuation of studies originally published in the January 1928 issue of the *Journal of Industrial Engineering Chemistry*. With an entirely inadequate time allowance, the paper was read before the Sanitary Engineering Division of the Society at its Annual Meeting in New York, N.Y., in January 1933. Subsequently, it was abstracted most briefly in technical news periodicals and in the March 1933 issue of Civil Engineering. It is hoped that, with its publication in Proceedings in full, the paper will fulfill a constant demand for advance copies of it and will receive the discussion that it obviously deserves.

News of Local Sections

Duluth Section

On May 15 the Duluth Section elected officers for the ensuing year as follows: Leland Clapper, President; A. C. Giesecke, First Vice-President; John Carson, Second Vice-President and Treasurer; and William E. Hawley, Secretary.

Georgia Section

A luncheon meeting of the Georgia Section was held on September 11 at the Atlanta Athletic Club. After a business session, Col. Lewis Brown, of Fort McPherson, in charge of reforestation work in the 4th Corps Area, gave a talk on various aspects of this work. A motion picture giving details of automatic protective gates for grade crossings was then shown. The meeting held by the Section on October 2 was devoted largely to business. A release from the Georgia State Highway Board on Public Works was read by J. Houstoun Johnston, consulting engineer for the Georgia Public Service Commission.

Metropolitan Section

On October 18, the Metropolitan Section commenced a new year of activity by holding a meeting devoted to discussion of the subject, "Codes for the Construction Industry Under the National Industrial Recovery Act." Speaking on this subject were Stephen F. Voorhees, John P. Hogan, and Carlton S. Proctor. Mr. Voorhees stated that the code is not a mandate imposed by Congress but simply a set of reasonable rules established by industry to govern fair competition and its own affairs. If the code does not work, governmental mandates for the management of the industry in question must be expected. However, he believes it much more intelligent and desirable for those in the construction industry to supervise their own affairs. At the close of the meeting refreshments were served. There were 375 present.

Milwaukee Section

A joint meeting of the Milwaukee Section and the Engineers Society of Milwaukee was held at the Milwaukee Athletic Club on May 17. This gathering was addressed by Alonzo J. Hammond, President of the Society, who spoke on "Advanced Planning as an Economic Problem." On July 14 a meeting was held for the transaction of business and discussion of the National Recovery Act. The provisions of this law were outlined by James L. Ferebee, Chief Engineer of the Milwaukee Sewerage Commission, and an animated discussion followed.

San Diego Section

The regular September dinner meeting of the San Diego Section was held September 28, at the Churchill Hotel. Charles P. Williams, former president of the Section and consulting engineer on the Rodriguez Dam, Baja California, spoke at length on the composition of cement for massive structures. He told of temperature-strength determinations made with cement of various compositions at the dam and outlined tentative specifications covering the composition of cement for massive structures. The attendance was 30.

Spokane Section

The August meeting of the Spokane Section was well attended. An interesting talk on the development of the Grand Coulee Dam site as compared with the sites of several other large dams was given by F. A. Banks, Construction Engineer for the Grand Coulee Dam. Discussion of the proposed code for engineers in the construction industry, which was the other topic discussed, elicited much favorable comment.

Student Chapter News

Cornell University

Several interesting meetings comprised the activities of the Cornell University Student Chapter during the past year. Included on the list of speakers who addressed these gatherings were the following: Homer R. Seely, Resident Engineer for the Central Section of the George Washington Bridge; Charles D. Curran, of the Corps of Engineers, U.S. Army; and Carl C. Cooman, civil engineer for the Rochester Gas and Electric Company. On November 21, Edward P. Lupfer, Society Director from the District, visited the Chapter. A dinner held in his honor was attended by representatives of the four Local Sections in the District and of the Syracuse University Student Chapter.

Kansas State College

Members of the Kansas State College Student Chapter played an important rôle in speaking before the meetings of the Chapter held during the school year just completed. In all, there were 14 of these meetings and a total attendance of 880. The outside speakers who addressed the Chapter were R. W. Crum, Director of the Highway Research Board of the National Research Council, and W. E. Baldry, City Engineer of Topeka, Kans. On April 20 members of the Chapter were guests of the Kansas State Section at a meeting held in Topeka.

Oregon State College

The Oregon State College Student Chapter has held nine meetings, attended by a total of 225, during the past year. A wide range of subjects was discussed at these meetings by outside speakers and members of the faculty. These included C. B. McCullough, Bridge Engineer, Oregon State Highway Department; Samuel Murray, an engineer of Portland, Ore.; and Harry S. Rogers, Dean of Engineering and Director of the Engineering Experiment Station at Oregon State College.

Pennsylvania State College

The Pennsylvania State College Student Chapter held 14 meetings during the past school year. These sessions, which attracted a total attendance of 397, were addressed by members of the Chapter and faculty as well as by outside speakers. At one meeting a motion picture, entitled the "Art of Welding," was shown, and all but three of the lectures given were illustrated by lantern slides or motion pictures. At the meeting held on April 25, William F. Miller, Engineer of Maintenance of Way for the Eastern Grand Division of the Pennsylvania Railroad, addressed a large and enthusiastic audience.

Polytechnic Institute of Brooklyn

Several inspection trips and seven meetings comprised the activities of the Polytechnic Institute of Brooklyn Student Chapter

during the past year. The trips included such points of interest as the Little Falls, N.J., power plant and the Rockefeller Center development in New York City. Among the well-known engineers who addressed the various meetings were the following: Robert Ridgway, Past-President of the Society and consulting engineer for the Board of Transportation, City of New York; Sigvald Johannesson, Designing Engineer of the New Jersey State Highway Commission; Roger W. Armstrong, Division Engineer for the Board of Water Supply, City of New York; and Ernest P. Goodrich, consulting engineer of New York, N.Y.

Purdue University

Meetings held by the Purdue University Student Chapter during the past year have been well attended, and the members have heard lectures upon various interesting aspects of modern engineering practice in this country and abroad. G. P. Springer, Assistant Professor of Civil Engineering at Purdue University; F. E. Richart, Research Associate Professor of Theoretical and Applied Mechanics at the University of Illinois; and M. R. Keefe, Vice-President of Ulen and Company, of Lebanon, Ind., were prominent among the speakers.

Rensselaer Polytechnic Institute

The different branches of civil engineering were well represented on the list of speakers who appeared before this Chapter during the past year. Among these were the following: David C. Coyle, consulting engineer of New York, N.Y.; George E. Beggs, Professor of Civil Engineering at Princeton University; J. E. Tonnelier, an engineer with the J. G. White Engineering Corporation; and Harold M. Lewis, an engineer with the Regional Plan Association of New York, N.Y.

Rhode Island State College

On April 19 the Rhode Island State College Student Chapter assisted at the annual meeting of the Rhode Island Highway Association. In addition, eight interesting meetings of the Chapter have been held during the school year, with a total attendance of 158.

Rice Institute

Illustrated Society lectures were shown at several of the meetings of the Rice Institute Student Chapter during the recently completed school year, and commercial engineering companies also furnished several interesting films. Other meetings were addressed by outside speakers, including R. W. Collins, Vice-President of the Southwestern Construction Company, and Joseph M. Howe, consulting engineer of Houston, Tex.

Rose Polytechnic Institute

Among those who spoke at 1932–1933 meetings of the Rose Polytechnic Institute Student Chapter were R. L. McCormick, Professor of Civil and Architectural Engineering at Rose Polytechnic Institute, and J. T. Hallett, Assistant Chief Engineer of the Indiana Highway Commission. At other meetings motion picture films on subjects of current engineering interest were shown by commercial organizations, including the Hanna Engineering Works and the Aluminum Company of America. Some slide lectures furnished by the Society were also enjoyed.

Stanford University

The members of the Stanford University Student Chapter attended numerous dinner meetings of the San Francisco Section of the Society during the past year. They also held 11 well attended meetings of their own. Numerous interesting lectures—many of them illustrated—were presented at these sessions. Included on the list of speakers were G. S. Strout, Manager of the Strout-Steffens Equipment Company, of San Francisco; R. L. Wing, Assistant Hydraulic Engineer, State Division of Water Resources, Sacramento; and Frederick H. Tibbetts, civil engineer of San Francisco.

Syracuse University

Illustrated lectures furnished by the Society proved of interest to the Syracuse University Student Chapter upon the occasion of several of its 1932-1933 meetings. A three-reel film illustrating the manufacture of iron and steel was loaned to the Chapter by the American Rolling Mill Company, of Middletown, Ohio. Motion pictures were also shown through the courtesy of the U.S. Department of Agriculture. On February 25 the Chapter was entertained at a joint meeting of the Syracuse and Ithaca Sections of the Society, held at Ithaca, N.Y. The membership of the Chapter shows an increase of 34 per cent over last year, and the attendance at meetings has increased 16 per cent.

Texas Technological College

The Texas Technological College Student Chapter reported at the close of the school year, that ten interesting meetings had been held. Entertainment on these occasions usually consisted of the presentation of an illustrated Society lecture, or a talk given by members of the Chapter or of the faculty. At the end of the semester a banquet was given to celebrate the installation of the new officers of the Chapter.

University of Alabama

During the school year 1932–1933, the membership of the University of Alabama Student Chapter was approximately three times greater than in any previous year, and the interest and activities of the members increased correspondingly. An engineering exhibition in miniature, consisting of a suspension bridge, the steel skeleton of a building under construction, and a concrete highway, mounted in relief, was an interesting feature of the meeting held on February 27. The members of the graduating class were given an inspection trip to the new Jefferson County sewage disposal plant.

University of Dayton

The University of Dayton Student Chapter participated in five inspection trips during the school year, 1932–1933. The points of interest visited were all in Dayton, except for the new Cincinnati Union Terminal, in Cincinnati. The members of the Chapter made this trip as guests of the Dayton Section of the Society. Throughout the year the Chapter sent representatives to the monthly meetings of the Section. Under the supervision of the faculty sponsor, Bernard T. Schad, the members of the Chapter were given practical experience in surveying. In addition to these activities, seven interesting meetings were held.

University of Illinois

The past year has been one of marked activity for the University of Illinois Student Chapter. The 15 meetings that were held attracted a total attendance of 1,622. On the list of well-known engineers who spoke at these meetings were the following: T. Chalkley Hatton, Consulting Sanitary Engineer of Milwaukee, Wis.; M. R. Keefe, Vice-President of Ulen and Company, of Lebanon, Ind.; and Willard T. Chevalier, Publishing Director of *Engineering News-Record*. On May 18 the annual banquet was held, with A. J. Hammond, President of the Society, as guest of honor. Mr. Hammond spoke on the subject, "The Solution of Practical Engineering Problems." During the spring the Chapter sponsored an inspection trip to Chicago for the purpose of seeing the construction work at the Century of Progress Exposition and of inspecting the bridges across the Chicago River.

University of Kentucky

Motion pictures furnished by the Society were an interesting feature of the programs presented by the University of Kentucky Student Chapter during the past school year. Biweekly meetings were held, with members of the Chapter or the faculty officiating as lecturers.

University of Minnesota

A wide range of engineering subjects was covered in the discussions presented at meetings of the University of Minnesota Student Chapter during the past year. Among the outside speakers were Lorenz G. Straub, of the Department of Hydraulics of the University of Minnesota; George M. Shepard, Chief Engineer of the Department of Public Works, City of St. Paul; and J. R. Stack, an engineer recently returned from Russia, where he was employed by the U. S. S. R. Motion pictures on manufacturing processes were shown at some of the meetings, and inspection trips to local engineering projects proved of value.

ITEMS OF INTEREST

Engineering Events in Brief

Civil Engineering for December

THE PROBLEM of controlling the high waters of the Mississippi River and confining them to locations where they will do the least property damage is an immense one. In an article on the machines in use on this work, T. B. Larkin, M. Am. Soc. C.E., District Engineer at Vicksburg, explains the magnitude of the problem and describes the types of equipment now found to be the most efficient by the contractors on the work of building the huge levees. The ten-year program of construction involves nearly two thousand miles of levees containing almost 650,000,000 cu yd of material, enough to cover an area the size of the District of Columbia 9 ft deep.

A difficult traffic problem has arisen at the southern connection of the Bronx River Parkway, built by the Westchester County (N.Y.) Park Commission a number of years ago. How the engineers for the Borough of the Bronx, New York, solved the difficulty by passing the connecting link under 233d Street, under the four tracks of the New York Central Railway, and over the Bronx River, is to be explained in the December issue by Arthur V. Sheridan, Assoc. M. Am. Soc. C.E.

Where large surfaces of concrete, such as highway slabs, are exposed to the air during curing, evaporation deprives the concrete of a part of the mixing water needed for the complete hydration of the cement. According to the tests conducted at Columbia University, by W. J. Krefeld, Assoc. M. Am. Soc. C.E., the damage or loss of strength is confined to the layers close to the surface and may amount to as much as 50 per cent in compressive strength and resistance to wear. To obtain the full advantage of curing mediums or impervious surface coatings in preventing evaporation of mixing water, they must be applied as soon as possible after pouring. The results of these tests, which cast new light on the effectiveness of curing methods now in use, will appear in the December issue.

Engineers of the Indiana Department of Conservation had an interesting job in the restoration of a century-old water mill in Spring Mill State Park, as described by Oren Reed, Assoc. M. Am. Soc. C.E., in an article in preparation for the next issue. With little physical evidence of the original mill except the stone walls of the building, some small pieces of the old wooden overshot wheel, and the original grinding stones, the engineers were able to reconstruct the mill and put it in working order for grinding corn, and to rebuild a small sash sawmill operated by an undershot wheel and a tub wheel. These two mills are now in operation for the instruction and pleasure of those who visit the park.

Interesting articles on aerial topographic mapping, on the characteristics of water wells, on fish ladders and screens, and on subway foundations are available and will be used as space permits. By special effort, the December issue will also contain the index to the articles appearing in Vol. 3 of CIVIL ENGINEERING. This will make it possible for those who preserve their issues to bind them immediately upon receipt of the last issue of the volume.

Prettyboy Dam

TO PROVIDE 61,500 acre-ft of additional storage for Baltimore's water supply system, the Prettyboy Dam has been completed on the upper reaches of Gunpowder Falls, 15 miles above the city's Lock Raven Reservoir. The dam is of gravity type, with a maximum height of 167 ft and a length of 845 ft. The central section, 274 ft long, forms an overflow spillway. Unsatisfactory foundation conditions revealed during excavation required a greater depth and a larger amount of excavation than had been anticipated, and a very considerable increase in the quantity of concrete. Contract payments on the dam have approximated $2,400,000. Such additional items as real estate, clearing, roads, and bridges will bring the ultimate cost to $3,500,000.

On the page of special interest in this number appears an etching of the dam made by Otto Kuhler during its construction. CIVIL ENGINEERING has been privileged to reproduce other examples of Mr. Kuhler's work. With his mechanical engineering training he is as much at home at the throttle of a locomotive as at the wheel of his etching press.

Legal Counsel at Washington Not Needed by Engineers and Architects

IN A STATEMENT released by American Engineering Council it is learned that the Treasury Department will look with much disfavor on those architects or engineers who retain legal counsel in Washington to aid them in securing professional contracts from the Department. In fact, the Department will be disposed to eliminate such architects and engineers from consideration altogether.

Early in the summer the Treasury Department learned that certain Washington lawyers had been soliciting engineers, architects, and others interested in obtaining Government business, on the ground that to retain such counsel would enhance the opportunities of the engineers and architects to obtain desirable contracts. This activity has been particularly prevalent in Western states.

The Treasury Department has not made public the names of the lawyers who engaged in this practice, feeling that probably they did not realize: (1) that their proposal was in itself a reflection on certain Government officials; and (2) that representation of the nature they would provide could not possibly have any bearing upon the selections made by the Department.

The Department desires to make its selections on the merits of each case alone. It is not disposed to prosecute any of the persons concerned, but it does want it emphatically understood that such a practice will be outlawed.

NEWS OF ENGINEERS

From Correspondence and Society Files

T. FARRANCE DAVEY, formerly Resident Engineer, Victoria Bridge, Milford Haven, Wales, has now accepted employment at the Hams Hall Power Station, City of Birmingham Electric Supply Department, Birmingham, England.

HERBERT E. PRATER is employed as a Junior Engineer in the design department of the U.S. Bureau of Reclamation, Denver, Colo.

HERMAN W. JENNINGS is associated with the U.S. Coast and Geodetic Survey as a draftsman on aerial mapping.

OLAF J. S. ELLINGSON, former city manager of Sherman, Tex., is now assistant general manager and purchasing agent in charge of the design and construction of buildings, bridges, and levees, for the same city.

PAUL MOLLER has accepted a position as Engineer of Bridge Design with the Royal Danish State Railway Company, of Copenhagen.

JAMEEL S. TOMA has accepted a connection as Assistant Engineer of the

EIGHTY-FIRST ANNUAL MEETING, January 17–20, 1934, in New York, N.Y., at Society Headquarters

Iraq Railways, with headquarters in Baghdad, Iraq.

ALEXANDER ALLAIRE has accepted a position with the Federal Emergency Administration of Public Works State Advisory Board, with headquarters in Little Rock, Ark.

JAMES G. ALLEN has accepted a position with the Tennessee Valley Authority. His headquarters are in Knoxville, Tenn.

HUNLEY ABBOTT, President of Abbott, Merkt and Company, Engineers and Architects of New York, has been appointed a member of the Technical Board of Review under Col. H. M. Waite, Deputy Administrator of the Federal Emergency Administration of Public Works in Washington.

CHARLES E. LEWIS has recently become connected with the South Dakota State Highway Commission, as engineer in the plans department.

J. GORDON LIPPINCOTT is teaching mathematics and fine arts at the Romford School in Washington, Conn.

FRANK J. MCCORMICK is now at Iowa State College, Ames, Iowa, where he is a research fellow in the department of mathematics.

FRAZIER P. LABOON, formerly employed as Assistant Engineer for the Interstate Commerce Commission, is now Assistant Highway Engineer with the U.S. Bureau of Public Roads, in Washington, D.C.

ARTHUR R. SORING is at present employed by the U.S. Engineers as an inspector on jetty construction in Newport, Ore.

ROSS WHITE has been appointed construction superintendent on Cove Creek Dam, with headquarters in Knoxville, Tenn.

LESLIE G. HOLLERAN, formerly Deputy Chief Engineer of the Westchester County Park Commission, has accepted a position as assistant to Arthur S. Tuttle, New York State Engineer for the Public Works Administration.

ALFRED R. GOLZÉ, formerly Assistant Engineer with the International Commerce Commission, Washington, D.C., is now employed in a similar capacity by the U.S. Bureau of Reclamation, in Denver, Colo.

ARTHUR H. ADAMS, C. M. CRAM, and CHARLES D. WAILES, JR., announce the opening of an office for the practice of civil and structural engineering in the First National Bank Building, Long Beach, Calif.

FRED E. SCHNEPFE has resigned as Vice-President of the Highway Engineering Bureau, in Washington, D.C., to become Director of Federal Projects, Federal Administration of Public Works, in the same city.

A. F. SAMUEL, JR., has accepted a position in the bridge department of the Wire Rope Division of John A. Roebling's Sons Company, Trenton, N.J.

B. THORLEIF BJORNSTAD is now employed by the U.S. Government as junior engineer for the survey and study of the Grand Coulee Dam Project in Washington. He has been assigned to the office of the Chief Engineer of the Bureau of Reclamation in Denver.

MERWIN ROSSON, until recently Construction Enginer for the Case Construction Company, of Los Angeles, is now a consulting engineer on pneumatic concrete construction in the City Engineer's Office, Long Beach, Calif.

W. W. HORNER, consulting engineer for the cities of St. Louis, Mo., and Dallas, Tex., announces the opening of an office in the International Office Building, St. Louis, for the practice of engineering. H. SHIFRIN, former Assistant Chief Engineer of sewers and paving for the City of St. Louis, will be associated with him.

DONALD MILLS has accepted a position as Designing Engineer for the newly created Sanitary Division of Arlington County, Virginia.

R. D. N. SIMHAM has recently become personal assistant in charge of the Directorate of Town Planning, Chepauk, Madras, India.

HERMAN SCHORER has taken a position with the U.S. Bureau of Reclamation, in Denver, Colo.

E. B. RAYBURN, JR., has resigned as Concrete Engineer for Charles R. Wernuth and Son, of Fort Wayne, Ind., to accept a position in a similar capacity with the Ready-Mixed Concrete Corporation, of Indianapolis.

HAROLD N. DAVIDSON, who was formerly in the employ of the Chicago office of the McClintic-Marshall Corporation, has now accepted an engineering connection with the G. H. Hammond Company of the same city.

T. HAROLD SANDERSON, formerly with the Engineers' Advisory Board of the Reconstruction Finance Corporation, Washington, D.C., has now joined the staff of the Illinois Steel Company (Department of Metallurgy and Inspection), of Chicago, Ill.

RUSSELL W. ABBOTT has accepted a position with Hoad, Decker, Shoecraft, and Drury, consulting civil engineers, of Ann Arbor, Mich.

L. ROY BOWEN, for the past twenty years in charge of the design and construction of bridges and buildings for the City of St. Louis, announces the opening of an office for the general practice of civil engineering and architecture in the American Trust Building, St. Louis, Mo.

HENRY J. TEBOW has resigned as Assistant Engineer with the Interstate Commerce Commission, with offices in Washington, D.C., to accept a position as Junior Engineer in the U.S. Bureau of Reclamation. His headquarters will be in Denver, Colo.

ARTHUR I. HEIM has accepted a connection as Chief Draftsman for A. E. Wheeler, 25 Broadway, New York, N.Y.

HORATIO SEYMOUR, formerly a consulting engineer of Santa Monica, Calif., is now employed as Cost Engineer by the Metropolitan Water District of Southern California, with headquarters in Banning.

GUY J. SEGHERS has established an engineering and surveying practice under his own name at 501 Interstate Bank Building, New Orleans, La. He was formerly a member of the firm, Ricketts, Seghers, and Dibdin, of the same city.

R. A. WILLIS has resumed his former connection with the Portland Cement Association, with offices in St. Louis, Mo. He has recently been connected with the City Plan Commission of St. Louis.

ALEX O. DORITY is again affiliated with the U.S. Coast and Geodetic Survey, in the Department of Hydrography and Topography. He is temporarily located in Flushing, N.Y.

IVAN C. CRAWFORD has tendered his resignation as Dean of the College of Engineering of the University of Idaho, to become State Engineer, Public Works Administration, with headquarters in Boise, Idaho.

WILLIAM J. RINEBOLD has accepted a position as county surveyor. His office is in Towanda, Pa.

ALBERT MOYER, formerly assistant to the president of the Vulcanite Portland Cement Company, of New York, N.Y., was recently elected president of this firm to succeed the late W. D. Lober.

LUIS A. DELIZ has been appointed Assistant Chief in the Bureau of Translations of the Legislature of Puerto Rico.

THEODORE E. SEELYE is now vice-president of Day and Zimmermann, Inc., engineers of Philadelphia, Pa. He was formerly employed in a similar capacity by Gannett, Seelye, and Fleming Engineers, Inc., of Harrisburg, Pa.

HENRY F. STUBBS has resumed his old connection as Construction Engineer for the Sumner Sollitt Company of Texas, with headquarters in San Antonio.

F. L. ADAMS has accepted a position with the Division of Investigations of the Public Works Administration in Washington, D.C.

ROLAND A. KAMPMEIER, formerly of Cedar Rapids, Iowa, is now employed as a Junior Engineer by the Tennessee Valley Authority, with headquarters in Denver, Colo., in the office of the U.S. Bureau of Reclamation.

G. B. GIFFORD HULL has accepted a position as Resident Engineer on the Shing Mun Valley Water Scheme, with offices in Hong Kong, China. He was formerly employed as Chief Resident Engineer, Water Supply from Johore, Singapore Municipality, Singapore, Straits Settlements.

Changes in Membership Grades

Additions, Transfers, Reinstatements, Deaths, and Resignations

From September 10 to October 9, 1933, Inclusive

Additions to Membership

Aldrich, Eugene Volney (Jun. '33), Care, U.S. Bureau of Public Roads, 802 Title and Trust Bldg., Phoenix, Ariz.

Bailey, William Atterbury (Jun. '33), 1412 Hawthorne Terrace, Berkeley, Calif.

Beckwith, William Percy (Assoc. M. '32), Overseer of Works, Gen. Penitentiary (Res., 22 Sackville Rd., Vineyard Pen), Kingston, Jamaica.

Beichmann, Ulrik Fredrik (Assoc. M. '33), With E. J. Müller, 308 Glen Line Bldg., Shanghai, China.

Berge, Finn Olaffsön (Assoc. M. '33), With E. J. Müller, 309 Glen Line Bldg., Shanghai, China.

Bryan, Lester Leon (Assoc. M. '33), Hydr. Engr., U.S. Geological Survey, Sacramento, Calif.

Dike, Oscar Dermit (Jun. '33), 3800 Thirty-fifth, West, Seattle, Wash.

Griffith, Joseph Gordon (Jun. '32), Camp Willoughby, West Burke, Vt.

O'Harra, Wayne Gilder (Assoc. M. '33), Chemist and Office Asst., State Highway Dept., Route 8, Box 577, Phoenix, Ariz.

Olander, Ralph Carl (Jun. '33), 901 Pearl St., Yankton, S. Dak.

Sahney, Jagdish Chandra (Jun. '33), Civ. Engr., Sahney Bldgs., Jhansi, India.

Smedberg, Nels Harold (Jun. '33), 16161 Forty-first Ave., N.E., Seattle, Wash.

Stubbs, Frank Lycurgus (Jun. '33), Asst. Res. Engr., State Highway Dept., Box 864, Del Rio, Tex.

Membership Transfers

Foight, Clarence Douglas (Assoc. M. '26; M. '33), Designing Engr., Div. of Bridges, Bureau of Eng. (Res., 2405 Hobson St.), Pittsburgh 16, Pa.

Goodman, Wallace Shufeldt (Assoc. M. '30; M. '33), County Engr., Bexar County, Court House (Res., 606 East Mulberry Ave.), San Antonio, Tex.

Ketter, E. F. (Assoc. M. '22; M. '33), Chf. Draftsman, United States Coal & Coke Co., Box 385, Gary, W.Va.

Turneaure, Frederick Eugene (Affiliate '97; Assoc. M. '02; M. '13; Hon. M. '33), Cons. Engr.; Dean, Coll. of Mechanics and Eng., Univ. of Wisconsin, Madison, Wis.

Reinstatements

Coddington, Edwin Foster, M., reinstated Sept. 20, 1933.

Miles, William John, Assoc. M., reinstated Sept. 25, 1933.

Moore, Leslie Dominick, M., reinstated Sept. 20, 1933.

Resignations

Cochran, John Andrews, Jun., resigned Sept. 20, 1933.

Faulkner, James David, Assoc. M., resigned Sept. 20, 1933.

Marion, Frank Ivichevich, Jun., resigned Sept. 22, 1933.

Deaths

Black, William Murray. Elected M., June 6, 1888; died Sept. 24, 1933.

Bowman, Clarence Henry. Elected M., Aug. 28, 1922; died Sept. 29, 1933.

Chase, Clement Edwards. Elected Jun., Oct. 1, 1912; Assoc. M., April 19, 1920; M., Oct. 21, 1924; died Sept. 18, 1933.

Diven, Alexander Samuel, 3d. Elected Assoc. M., Dec. 28, 1931; died Sept. 9, 1933.

Foote, Arthur DeWint. Elected M., May 7, 1884; died Aug. 24, 1933.

Ginsberg, Nathan. Elected Jun., Oct. 14, 1930; died Nov. 24, 1932.

Jenkins, Charles Edwin. Elected M., May 7, 1913; died Sept. 29, 1933.

Morrison, Thomas Montgomery. Elected M., Jan. 14, 1924; died Sept. 18, 1933.

Scotten, Frank. Elected M., Aug. 31, 1909; died Sept. 13, 1933.

Smith, Raymond Hewitt. Elected M., Dec. 15, 1924; died Aug. 21, 1933.

Ward, George Clinton. Elected M., Feb. 10, 1930; died Sept. 11, 1933.

Wasser, Thomas James. Elected Assoc. M., April 3, 1907; died Sept. 21, 1933.

Wentz, Foster Pratt. Elected Assoc. M., Jan. 13, 1919; died March 29, 1933.

White, Ivan Forrest. Elected Assoc. M., Oct. 14, 1930; date of death unknown.

TOTAL MEMBERSHIP AS OF OCTOBER 9, 1933

Members	5,773
Associate Members	6,276
Corporate Members	12,049
Honorary Members	19
Juniors	2,893
Affiliates	112
Fellows	5
Total	15,078

Men Available

These items are from information furnished by the Engineering Societies Employment Service, with offices in Chicago, New York, and San Francisco. The Service is available to all members of the contributing societies. A complete statement of the procedure, the location of offices, and the fee is to be found on page 97 of the 1933 Year Book of the Society. To expedite publication, notices should be sent direct to the Employment Service, 31 West 39th Street, New York, N.Y. Employers should address replies to the key number, care of the New York Office, unless the word Chicago or San Francisco follows the key number, when the reply should be sent to the office designated.

Construction

Construction and Field Engineer; M. Am. Soc. C.E.; 37 years experience on railroad, highway, and building construction. Also considerable experience on marine work, pile driving, and dredging. Available immediately. Location immaterial. D-2567.

Construction Engineer; Assoc. M. Am. Soc. C.E.; 49; married; licensed, New York and New Jersey; 24 years experience; building contractors' superintendent of construction; practical; architectural drafting and field supervision; mechanical equipment; structural design in concrete, steel, and timber. Salary moderate. C-2185.

Concrete Specialist; Jun. Am. Soc. C.E.; 32; 5 years experience on construction projects in charge of field testing laboratories for the control of concrete aggregates, proportioning mixes, and testing concrete. C-3432.

Concrete Technician; Assoc. M. Am. Soc. C.E.; C.E., University of West Virginia; 31; married; 8 years construction experience, specializing in concrete. Qualified to take charge of concrete field laboratory and concrete inspection force, supervising testing, design of concrete mixtures, and concrete control. Can make special investigations in connection with concrete and prepare reports and discussions. C-8022.

Design

Bridge and Structural Engineer; M. Am. Soc. C.E.; 41; married; B.S. and M.S.; 17 years experience in designing and directing design work on highway and railroad bridges of all types in steel, stone, and concrete and other structures; 2 years teaching bridge engineering and theory of structures Available immediately. D-1695.

Civil Engineer; Assoc. M. Am. Soc. C.E.; 37; married; graduate; state licenses; 10 years experience, surveying, design, and construction. Railroad, highway, parkway, harbor, and tall building projects. Completely familiar with the design of rigid-frame bridges, reinforced concrete or steel, single or multiple span, square or skew. Available immediately. D-1496.

Structural and Hydraulic Engineer; Assoc. M. Am. Soc. C.E.; 32; married; graduate of Massachusetts Institute of Technology; 10 years experience as structural designer and part-time assistant engineer in connection with over twenty large steam and hydro-electric power plants and industrial buildings. New England or the East preferred. D-42.

Graduate Civil Engineer; Jun. Am. Soc. C.E.; 26; 1/2 years experience in design, specifications, drafting, construction, and surveying. Design, detail, preparation of plans and specifications, and supervision of municipal improvements, highways, and concrete structures; excellent draftsman. Salary secondary to demonstrating worth to employer. D-2559.

CIVIL AND STRUCTURAL ENGINEER; Jun. Am. Soc. C.E.; 29; B.S. in C.E. and C.E. degrees; about 5 years experience in New York City as a designer, detailer, draftsman, checker, and estimator of steel and reinforced concrete. References and samples of work sent on request. C-6186.

STRUCTURAL DESIGNER AND SALES ENGINEER; M. Am. Soc. C.E.; 39; married; graduate C.E.; licensed; 18 years experience in structural designing, managing steel fabricating plant, and selling. Large acquaintance among architects, engineers, builders, and contractors in northern New Jersey. A-5489.

EXECUTIVE

CIVIL ENGINEER; Jun. Am. Soc. C.E.; married; graduate C.E.; professional engineer, licensed New York State; 9 years general experience in field and office; construction, design, and investigations; 3 years assistant supervision for municipal highway department. Will consider any engineering position. Available immediately. D-2315.

STRUCTURAL ENGINEER; M. Am. Soc. C.E.; 46; married. Connected with steel fabricating business for over 20 years. Offers exceptional qualifications in estimating, designing, and sales as well as district representative for western Pennsylvania and Ohio. C-5095.

INDUSTRIAL, POWER, PLANNING, AND HOUSING; Assoc. M. Am. Soc. C.E.; seeks connection with operating company, service organization, or new enterprise. Wide experience—20 years in United States and Mexico—on important work with outstanding organizations; design, construction, financial, business examinations, legal, and managerial. Excellent references and scholastic preparation. Family. C-154.

WANTED—Position as Chief Engineer, Plant Manager, or Plant Engineer; Assoc. M. Am. Soc. C.E.; 27 years thorough and varied experience along these lines in several industries. Principal asset has been the ability to reduce operating and maintenance costs and, at the same time, improve the plant, the equipment, and the working conditions. B-5294.

PATENT ATTORNEY; Assoc. M. Am. Soc. C.E.; capable of organizing and managing patent department. University graduate. Professional engineering degree. Member of New York Bar. Registered United States and Canadian patent attorney. Broad business experience; 8 years patent experience with old established patent law firm and patent department of large corporation. B-1819.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; single; B.S. in C.E.; 2 years survey, design, and construction of highways; 3 months structural steel detailing; 2 years water works distribution surveys in Mid-Western cities, including testing of pumps and water measuring and storage equipment, preparation of flow charts, maps, reports, and recommendations for system improvements. Available now. Location anywhere. C-6123.

OFFICE ENGINEER-ARCHITECT; M. Am. Soc. C.E.; Am. Inst. Arch.; 39; married; American; Cornell University; 12 years structural and architectural design, drafting, specifications, detailed estimating, and supervision, on residences, churches, hospitals, schools, and commercial buildings; 5 years projection—design of structures, maps, profiles, and estimates of highway and railway location; experience in United States and Latin-America. Fluent Spanish; technical vocabulary. D-2472.

CIVIL ENGINEER; Assoc. M. Am. Soc. C.E.; college graduate; 38; married; specialized in reinforced concrete construction. For the past 9 years in charge of the design, estimate, detailing, and supervision of fireproof floor systems and all types of buildings. Desires permanent connection in metropolitan New York or New Jersey. B-7608.

EXECUTIVE SANITARY ENGINEER; M. Am. Soc. C.E.; 40; married; graduate C.E.; 18 years executive experience; broad experience in design, operation, and construction of water and sewerage works. Expert witness in sanitation and public health relative to water and sewage, also in water and sewerage works valuation. A-2785.

ENGINEERING AND CONSTRUCTION EXECUTIVE; M. Am. Soc. C.E.; 28 years experience in heavy construction, mostly as manager or superintendent. Dredging, irrigation, and drainage. Railroad construction, dock and harbor improvement, roads, and big sewers. Plain and reinforced concrete. Available on 30 days notice. Will go anywhere. C-3921.

JUNIOR

CONSTRUCTION ENGINEER; Jun. Am. Soc. C.E.; graduate of Rose Polytechnic Institute; 3 years experience as structural draftsman; 1 year with general contractor as labor foreman. Any professional job will be accepted, regardless of location. Speaks and writes German fluently. D-2551.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 29; B.S. in C.E.; 1 year field and office work on topography surveys; 4 1/2 years varied structural experience in bridge department of railroad, including investigation of stresses and capacities and reinforcement of various types of highway and railroad bridges. References. Available immediately. D-2574.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; single; B.S. in C.E., 1930, Drexel Institute. Highway experience, drafting, design, surveys, and construction. Last 3 years chief of party, New Jersey State Highway Department; 6 months aerial survey; 6 months U.S. Engineers. Passed U.S. Civil Service Junior Engineer Examination. Desires opportunity any branch engineering. Available. Location immaterial. D-2588.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; New York University, 1930; 26; 3 1/2 years with general contractor and on Holland Tunnel, on sub-river railroad tunnels. Charge of hydrographic surveys, dredging, soundings, building inspection, and reports. Estimating, drafting, and designing in concrete, steel, waterproofing, timber, etc. Wants work with contractor anywhere; available short notice. D-1921.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; graduate, 1930; neat; industrious; ambitious; resourceful. Speaks Italian, Spanish, and English; good mathematician. Competent draftsman; 4 years experience. Capable performing, supervising difficult drafting and computations for construction drawings, highways, sewers, pipe lines; 2 1/2 years experience highways. Desires work with reputable concern, consulting engineer, or as assistant in university. C-7279.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 26; single; B.S., C.E., Georgia School of Technology, 1930; 2 years experience in aerial photographic surveying, including drafting and tracing of line maps, cost estimating, preparing bids, computation of control data and ratios, and darkroom and mosaic work. Knowledge of Spanish. Desires opportunity in any branch of civil engineering. Domestic or foreign location. Available. D-2595.

CIVIL ENGINEER; Jun. Am. Soc. C.E.; 27; single; B.S. in C.E., Rutgers University, 1930; 1 1/2 years transitman Essex County (New Jersey) Highway Department; passed New Jersey State Civil Service Senior Draftsman examination. Desires working or teaching position in any branch of civil engineering, preferably one involving mathematics. D-663.

MISCELLANEOUS

SANITARY AND CIVIL ENGINEER; Jun. Am. Soc. C.E.; B.S. and M.S. degrees; 29; married; registered professional engineer in two states; 6 years experience. Well qualified for water, sewerage, and stream pollution work. C-7471.

SALES

ENGINEERING GRADUATE; Jun. Am. Soc. C.E.; desires position as sales, sanitary, mining, or municipal engineer. Age 30. Experience 5 years sanitary and chemical field; 4 years mining, municipal, and general engineering work, both office and field. Had complete responsible charge of engineering work for 9 years. Technical education supplemented with cooperative industrial work. References. D-2586.

RECENT BOOKS

New books of interest to Civil Engineers, donated by the publishers to the Engineering Societies Library, or to the Society's Reading Room, will be found listed here. A comprehensive statement regarding the service which the Library makes available to members is to be found on page 87 of the Year Book for 1933. These notes regarding the books are taken from the books themselves, and this Society is not responsible for them.

AIR CONDITIONING. By J. A. Moyer and R. U. Fittz. New York and London, McGraw-Hill Book Co., 1933. 390 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $4.

The first half of this book presents the theory of air cooling and discusses such matters as air filtering, cooling methods, refrigeration, humidity control, fans, etc. The second half considers the design of plants for office buildings, theaters, restaurants, factories, cars, and residences. Design requirements are considered and the necessary computations for various structures are given.

DESIGNING FOR ARC WELDING (Second Lincoln Arc Welding Prize Competition Papers). Edit. by A. F. Davis. Cleveland, Ohio, Lincoln Electric Co., 1933. 424 pp., illus., diagrs., charts, tables, 9 × 6 in., cloth, $2.50.

This volume contains 19 of the papers submitted in the second Lincoln Arc Welding Prize Competition, including the winners of the six principal prizes. The papers show applications of the use of arc welding in the design of machinery, ships, buildings, bridges, large containers, pipes, and pipe fittings.

ENERGETISCHE GRUNDLAGEN DER GASTECHNIK. (Kohle, Koks, Teer, Band 30). By F. Schuster. Halle (Saale), Wilhelm Knapp, 1933. 254 pp., diagrs., charts, tables, 10 × 7 in., paper, 17 rm.

Chemists and engineers whose work includes the handling of gases as raw materials, intermediate or main products, will find this a very useful reference work. A collection of physico-chemical formulas and numerical data.

HEALTH AND ENVIRONMENT. By E. Sydenstricker. New York and London, McGraw-Hill Book Co., 1933. 217 pp., charts, tables, maps, 10 × 6 in., cloth, $2.50.

This monograph reviews the available factual material upon the question of the extent to which health is affected by geographic environment, by urban or rural life, by economic and social status, and by occupation.

HYDRAULICS. By H. W. King and C. O. Wisler. 3 ed. New York, John Wiley & Sons, 1933. 292 pp., diagrs., charts, tables, 9 × 6 in., cloth, $2.75.

A presentation of the fundamental principles of hydraulics and their application in engineering practice, intended for beginning courses in the subject and also as a reference book. This edition has been thoroughly revised and partly rewritten. A discussion of the fundamental principles of fluid flow has been added, as well as a chapter upon non-uniform flow in open channels.

INLAND TRANSPORTATION, PRINCIPLES AND POLICIES (a revision and extension of *Railway Transportation*). By S. L. Miller. New York and London, McGraw-Hill Book Co., 1933. 822 pp., charts, maps, tables, 9 × 6 in., cloth, $4.

Professor Miller has thoroughly revised his well-known treatise on railway transportation and extended it to include other forms of inland transportation by motor, airplane, waterway, and pipe line. The book is intended for those who wish to understand the existing transportation problem and the possibilities of the various "solutions" that have been proposed.

CURRENT PERIODICAL LITERATURE

Abstracts of Articles on Civil Engineering Subjects from Magazines in This Country and in Foreign Lands

Selected items from the current Civil Engineering Group of the Engineering Index Service, 29 West 39th Street, New York, N.Y. Every article indexed is on file in The Engineering Societies Library, one of the leading technical libraries of the world. Some 2,000 technical publications from 40 countries in 20 languages are received by the Library and are read, abstracted, and indexed by trained engineers. With the information given in the items which follow, you may obtain the article from your own files, from your local library, or direct from the publisher. Photoprints will be supplied by this library at the cost of reproduction, 25 cents per page, plus postage, or technical translations of the complete text may be obtained at cost.

BRIDGES

CONCRETE FLOORS. Long Precast Bridge Slabs Carry Tracks Without Ballast. *Ry. Age*, vol. 95, no. 6, Aug. 5, 1933, pp. 209–211. Canadian National Railway completed two single-track bridges in which track ballast is eliminated completely and rails are set directly on oak cushion strips flush with top surface of deck slab; details of joint and reinforcing; equipment.

CONSTRUCTION. Cutting Edges for San Francisco Bay Bridge, W. E. Emmett. *Western Construction News and Highways Bldr.*, vol. 14, Aug. 1933, pp. 350 and 351. Description and method of construction of steel cutting edges for bridge-pier caissons.

FRANCE. Le nouveau pont suspendu de Veurey, sur l'Isère, G. Leinekugel Le Cocq. *Génie Civil*, vol. 103, no. 8, Aug. 19, 1933, pp. 173–178, 1 supp. plate. Design and construction of recently completed stiffened suspension bridge, 209.35 m in span, over the Isère River at Veurey; roadway is 5.9 m wide; details of foundations, reinforced concrete towers, and steel cables; testing of bridge.

GOLDEN GATE. Golden Gate Bridge. *Engineer*, vol. 156, no. 4049, Aug. 18, 1933, pp. 164–166. Suspension bridge connecting San Francisco and Marin County. Similar description previously indexed from various sources.

GREAT BRITAIN. Queen's Park Bridge, Heywood. *Concrete and Constr. Eng.*, vol. 28, no. 8, Aug. 1933, pp. 466–470. Design of reinforced-concrete arch highway bridge, 409 ft total length, comprising central arch 192 ft in span.

IRELAND. Concrete Bridge Construction in Northern Ireland. *Ry. Engr.*, vol. 54, no. 641, July 1933, pp. 209–215. Structural details of several concrete-arch railroad viaducts, with individual spans up to 89 ft in length.

PIERS, FOUNDATIONS. Artificial Islands Aid Sinking of Pier Caissons. *Construction Methods*, vol. 15, no. 9, Sept. 1933, pp. 301–302. Use of artificial islands in starting and sinking, by open dredging, of foundation caissons for three piers of the new reinforced-concrete multiple-arch Grey Street Bridge across the Brisbane River, at Brisbane, Australia; pneumatic pressures up to 60 lb per sq in. required to bottom caissons in bedrock at a maximum depth of 107 ft below high tide.

RAILROAD. Girderless Flat-Slab Bridges for Grade Crossings, M. Hirschthal. *Eng. News-Rec.*, vol. 111, no. 12, Sept. 21, 1933, pp. 344–347. Experience of Delaware, Lackawanna and Western Railroad indicating that substantial economies are possible with relatively thin slabs, simple formwork, and reduced excavation or fill; comparison of girderless flat-slab bridge with one using one-way reinforced slab continuous over three piers and simply supported at abutments; skew bridges; foundation plan of overhead crossing at Kearny, N.J.

STEEL, PROTECTIVE COATINGS. Gunite Retains Integrity on Oregon Road Bridges, C. B. McCullough. *Eng. News-Rec.*, vol. 111, no. 9, Aug. 31, 1933, pp. 259 and 260. 1932 survey of condition of steel arch bridge in Oregon City and of Mackenzie River steel truss bridge indicates that incasement placed in 1922 and 1929 shows no deterioration with the exception of a few hair cracks.

STEEL ARCH. Storstrom Bridge. *Concrete and Constr. Eng.*, vol. 28, no. 9, Sept. 1933, pp. 547–550. Structural features of 2-mile combined bridge being built for the Danish State Railways; center spans are 450 ft long.

STEEL GIRDER. Rail and Road Bridges on Same Foundations. *Eng. News-Rec.*, vol. 111, no. 10, Sept. 7, 1933, pp. 284 and 285. Design and construction of structures over the new Beauharnois Canal in Quebec consisting of two plate-girder bridges, over 3,000 ft long, supported on a single set of 34 concrete piers sunk to rock and sealed under pressure; steel erection was carried out by means of locomotive cranes operating on a temporary track placed alongside the bridge.

SUSPENSION, CONSTRUCTION. Suspension Bridge Erection, R. E. Brock. *Western Machy. and Steel World*, vol. 24, no. 9, Sept. 1933, pp. 266–268 and 288A. Evolution of suspension bridge construction methods in the United States; wire details; testing methods; cable spinning; reel for bridge wire.

WELDING. Fighting Corrosion in Bridge Maintenance, W. R. Roof. *Welding Engr.*, vol. 18, no. 7, July 1933, pp. 18–20. Laboratory tests show that wrought-iron reinforcing plates welded to existing beams will greatly reduce the corrosion caused by brine drippings, besides adding strength to the structure.

BUILDINGS

AUDITORIUMS, WINNIPEG, MAN. Construction of New Municipal Auditorium at Winnipeg, Man., D. A. Ross. *Can. Engr.*, vol. 65, no. 10, Sept. 1933, pp. 3–6 and 10. Design, construction, and equipment of building occupying entire city block; cost $1,110,000.

CONSTRUCTION. Mobile Gantry Crane Erects 60-Ton Columns. *Construction Methods*, vol. 15, no. 9, Sept. 1933, pp. 36–39. Use of Mobile gantry crane of special design to erect 62 monolithic limestone columns weighing 60 tons each in 29 working days at the new Mellon Institute of Industrial Research, Pittsburgh.

EARTHQUAKE EFFECTS. Design of Steel Buildings to Resist Earthquakes, H. H. Tracy. *Western Machy. and Steel World*, vol. 24, no. 8, Aug. 1933, pp. 226–228. Importance of erecting buildings capable of resisting earthquake forces; application of arc welding in such structures; basis of calculation of seismic force; expense is justified by saving in insurance types of steel framing; design values of unit stress; tests of electrodes; importance of inspection. Before Am. Welding Soc.

GYMNASIUMS. Engineering Features of Modern Gymnasium, E. E. Seelye. *Eng. News-Rec.*, vol. 111, no. 8, Aug. 24, 1933, pp. 219 and 220. Description of new Payne Whitney Gymnasium at Yale University, consisting of a tower flanked on either side by auditorium units housing pools, rowing tanks, basketball courts, and numerous work rooms; exhibition swimming pool is surrounded by tiers of steeply banked seats, which will accommodate 2,200 spectators.

HIGH BUILDINGS, NEW YORK. Das Empire State-Gebaeude in New York, H. Raethling. *VDI Zeit*, vol. 77, no. 32, Aug. 12, 1933, pp. 870–872. Compilation on design and construction of Empire State Building in New York City, based on several previously indexed articles.

CITY AND REGIONAL PLANNING

SLUMS. Slum Clearance, J. E. Acfield. *Inst. Mun. and County Engrs.—Journal*, vol. 60, no. 3, Aug. 1, 1933, pp. 222–239 (discussion) 239–246. Statistical analysis of slum conditions in Manchester, Sheffield, Leeds, Liverpool, Bristol, and other British cities.

STOCKHOLM, SWEDEN. Stockholm Town Planning Competition (Lower Norrmalm), E. P. Wretlind. *Inst. Mun. and County Engrs.—Journal*, vol. 60, no. 6, Sept. 12, 1933, pp. 416–420. History of the city and development of its plan since the seventeenth century; present-day city planning problems of Stockholm.

CONCRETE

AGGREGATES. New Acquired Knowledge of Cement and Concrete Aggregates, F. O. Anderegg. *Rock Products*, vol. 36, no. 8, Aug. 25, 1933, pp. 62–64. Developments that have taken place in the theory of portland cement and concrete aggregates and in the application of the theory to practical purposes; clinker grinding; size analysis of cement; setting of cement; heat of hydration; high-early strength; curing of concrete; corrosion resistance; volume change; masonry cements; pozzuolans; concrete aggregates. Bibliography.

COLUMNS, COMPOSITE. Die Vereinigung der Stahl- und Eisenbetonsaeulem, B. Enyedi. *Montanistische Rundschau*, vol. 25, no. 14, July 16, 1933 (supp.), pp. 1–3. Combined steel and reinforced-concrete columns; examples and features of improved types of composite steel-concrete columns, first developed by Emperger.

CURING. Cotton Mats for Curing Concrete. *Pub. Roads*, vol. 14, no. 5, July 1933, pp. 73–80 and 92. Report on tests by the U.S. Bureau of Public Roads to determine the various thicknesses for the protection of concrete while curing; insulating properties of various thicknesses of mat; modulus of rupture tests; effect of various surface coverings on temperature of concrete exposed to sun's rays; effect of color of cement; comparative moisture contents and strengths of mortar specimens cured under burlap and cotton.

DESIGN. Reinforced Concrete Versus Steel. *Structural Engr.*, vol. 11 (New Series), no. 9, Sept. 1933, pp. 369–378. Proceedings of debate at a meeting of the Institution of Structural Engineers consisting of the following: "Case for Reinforced Concrete," N. B. Liversedge; "Case for Structural Steel," A. J. Hodgkinson.

HEAT STRESSES. Thermal Stresses in Structures, A. J. Ashdown. *Concrete and Constr. Eng.*, vol. 28, no. 8, Aug. 1933, pp. 471–479. Theoretical mathematical discussion of thermal stresses in continuous beams, box culverts, and tanks.

HOOVER DAM PROJECT, CONCRETE CONSTRUCTION. Cableways Place Hoover Dam Concrete, J. P. Yates. *Western Construction News and Highways Bldr.*, vol. 8, no. 15, Sept. 1933, pp. 377–381. Equipment for placing 4,000,000 cu yd of concrete; location of cableways; runways; hoist motors and control; tower travel; operating ropes; carriages and fall blocks; track cable.

MIXING. Proportioning Materials for Concrete, H. N. Walsh. *Concrete and Constr. Eng.*, vol. 28, no. 8, Aug. 1933, pp. 487–502; see editorial comment on pp. 447 and 448. Experimental study of proportioning and mixing methods for obtaining concrete of satisfactory workability, density, and strength. Before Inst. Civ. Engrs., Ireland.

MORTAR, SUGAR EFFECT. Effect of Sugar on Mortars, J. Basso. *Concrete and Constr. Eng.*, vol. 28, no. 7, July 1933, pp. 433 and 444. Results of Spanish tests showing that sugar has a favorable effect on white lime mortars and an injurious effect on portland-cement mortars.

SPECIFICATIONS. Report of Committee C-9 on Concrete and Concrete Aggregates. *Am. Soc. Testing Materials—Advance Paper*, no. 39, meeting, June 26–30, 1933, 21 pp. Recommendations affecting standards; tentative specifications for ready-mixed concrete and light-weight aggregates; tentative method of test for absorption by aggregates; tentative method of field test for absorption of mixing water by aggregates.

TROPICS. Betons coloniaux, R. Feret. *Revue des Matériaux de Construction et de Travaux Publics*, no. 284, May 1933, pp. 157–164. Experimental data on cements, concretes, and mortars under tropical conditions; attempt made to explain causes of decomposition of concretes in tropical countries.

DAMS

CALIFORNIA. Rebuilding Earth-Fill Dam After Unstable Foundation Wrecks Initial Structure, F. W. Hanna. *Water Works Eng.*, vol. 86, no. 15, July 26, 1933, pp. 726 and 727. Comple-

tion of rolled earth-fill Lafayette Dam near Oakland, Calif., 140 ft high, 1,400 ft long, and 30 ft wide at top, which failed during the process of construction; dam, as now completed, has a maximum height of 104 ft above original ground surface and a top width of 181 ft; inlet and spillway arrangements.

CONCRETE. New Service Reservoir for Luton Water Co., H. B. Rowntree. *Water and Water Eng.*, vol. 35, no. 422, Aug. 21, 1933, pp. 489–492. Description of new covered reinforced concrete service reservoir with capacity of 5,300,000 gal, recently put into service by the Luton Water Company.

CONCRETE ARCH, NEVADA. Construction of Cat Creek Dam, W. O. Hiltabidle, Jr. *Military Engr.*, vol. 25, no. 143, Sept.–Oct. 1933, pp. 420–422. Description of recently completed concrete arch dam, 115 ft maximum height and 236 ft long, at the Naval Ammunition Depot, Hawthorne, Nev.

CONCRETE GRAVITY, CALIFORNIA. Vibrated No-Slump Concrete Placed in Pine Canyon Dam. *Construction Methods*, vol. 15, no. 7, July 1933, pp. 18–21. Construction of concrete gravity dam 240 ft high for the water supply of Pasadena, Calif.; aerial tramway; bulk cement pumping; concrete-handling cableways.

COREWALLS. Corewall of 31 Caissons Sunk Under Air. *Eng. News-Rec.*, vol. 111, no. 8, Aug. 24, 1933, pp. 215–219. Construction of concrete corewall, 1,500 ft long, of Quabbin Reservoir dike, 135 ft high, for Boston water supply; concrete caissons, 9 ft by 45 ft, sunk end to end; 140 ft maximum depth to bedrock; pumping ahead of construction lowered groundwater level 80 ft and reduced air pressure to 18 lb; trial caisson sunk before pumping required 48 lb of air.

EARTH. Description of Field and Laboratory Methods, R. R. Proctor. *Eng. News-Rec.*, vol. 111, no. 10, Sept. 7, 1933, pp. 286–289. Second of four articles on the design and construction of rolled-earth dams; air-void and dry-weight curves; soil plasticity; needle determinations of moisture content and compaction; field and laboratory methods; soils suitable for dams; placing soil in test equipment.

FOUNDATIONS. Electrical Study of Dam Foundations, M. Lugeon and C. Schlumberger. *Min. Mag.*, vol. 48, no. 6, June 1933, pp. 340–345. Application of electrical prospecting methods to the study of dam foundations and associated structures.

GREAT BRITAIN. New Reservoir for Hastings. *Water and Water Eng.*, vol. 35, no. 422, Aug. 21, 1933, pp. 499 and 500. Description of new storage reservoir having a capacity of 188,000,000 gal, formed by pugged earth-fill embankment; the spillway consists of bell-mouthed vertical concrete shaft located on branch of outlet tunnel.

HOOVER DAM PROJECT, CONSTRUCTION. Preparing Black Canyon for Boulder Dam. *Construction Methods*, vol. 15, no. 8, Aug. 1933, pp. 36–39. Cofferdam construction and canyon excavation; record of material handled and moved.

HYDRAULIC FILL. Improved Internal Drainage for Hydraulic-Fill Dams, E. McD. Moore. *Eng. News-Rec.*, vol. 111, no. 8, Aug. 24, 1933, pp. 224 and 225. Proposed modifications of current methods of constructing hydraulic-fill and semi-hydraulic-fill dams to improve internal drainage by creating definite channels of permeable material; method of making trestle fills to improve interior drainage; construction procedure; drainage requirements; form of drains.

MODEL TESTING. Hydraulic-Model Tests for Boulder Dam Spillways, E. W. Lane. *Eng. News-Rec.*, vol. 111, no. 6, Aug. 10, 1933, pp. 155–159. Results of tests, made at field laboratory at Montrose, Colo., of models of a side-channel spillway with drum gates with a capacity of 400,000 cu ft per sec; record size models on 1–20 scale use flow of 112 cu ft per sec; conditions of tunnel discharge.

RESERVOIRS, FLOODS. Floods in Relation to Reservoir Practice. *Surveyor*, vol. 84, no. 2170, Aug. 25, 1933, p. 166. Abstract of the Interim Report of the Floods Committee of the Institution of Civil Engineers in regard to the magnitude of floods in relation to reservoir practice in Great Britain; basis of recorded observations; rainfall and run-off; effect of storage on overflow; catastrophic floods.

ROCK-FILL, FAILURES. Data on Castlewood Dam Failure and Flood, J. E. Field. *Eng. News-Rec.*, vol. 111, no. 10, Sept. 7, 1933, pp. 279 and 280. Analysis of rain storm which caused the flood that brought about the failure of the earth dam described in article previously indexed from issue of Aug. 10, 1933, p. 179; structural weakness of Castlewood Dam.

FLOOD CONTROL

CHINA. The Yellow River—Major Flood Menace in China, A. M. Shaw. *Eng. News-Rec.*, vol. 111, no. 9, Aug. 31, 1933, pp. 261–265. Survey of flood conditions and flood control in the basin of the Yellow River and other great rivers of China; study of historical records for 2,000 years showing many changes in location and cross sectional area of the channel of the Yellow River.

DISCHARGE. Manner of Flow of River in Flood and Flood Warnings, D. Fison. *Inst. Engrs. Australia—Journal*, vol. 5, no. 7, July 1933, pp. 230 and 231. Discussion by W. H. R. Nimmo, of paper previously indexed from issue of March 1933.

GREAT BRITAIN. Flood Danger to London, R. A. Ryves. *Civ. Eng. (London)*, vol. 28, no. 324, June 1933, pp. 216–219. Causes of abnormally high tides; remedial measures; part played by winds in causing abnormally high tides in Thames estuary; estimates and measurements of subsidence in London.

FLOW OF FLUIDS

FLOW OF WATER, SAND. Flow of Water in Sand, E. M. Taylor and H. Lal Uppal. *Engineer*, vol. 156, no. 4047, Aug. 4, 1933, pp. 107 and 108. Method of studying the flow of water under works; flow under impervious floor; effect of sheet pile at upstream end of impervious floor; methods described may be of value in studying the flow of water in models of weirs and other works on sand foundations.

FOUNDATIONS

CAISSONS, CONCRETE CONSTRUCTION. Concrete Caissons Sunk by Air-Lift Pumping. *Eng. News-Rec.*, vol. 111, no. 9, Aug. 31, 1933, pp. 249–250. Construction of landing jetty at Le Verdon, France, with direct rail connection to Bordeaux, founded on 96 cylinder caissons sunk by sand-ejection process; details of supporting reinforced concrete caissons and sinking equipment; telescopic axle for suspending caisson while lowering it to position for sinking.

DESIGN. Foundations, J. A. M. Sandover. *Structural Engr.*, vol. 11 (New Series), no. 8, Aug. 1933, pp. 338–351. Design of foundations, taking into account properties of soils, wind loading, and earthquakes; preliminary investigation of soil; types of foundations; piles; concrete piles; driving piles; caissons; economics.

EXCAVATION. Mass-Haul Diagram for Earthworks, H. C. Platts. *Surveyor*, vol. 84, no. 2170, Aug. 25, 1933, pp. 159–161. Uses and construction of diagram; position and concentration of cuttings and fillings; balance points; direction of haul; mass haul; average haul.

PILES, WOODEN, DECAY. Wood Borers Remove Piles from Building Foundations, C. A. P. Turner. *Eng. News-Rec.*, vol. 111, no. 6, Aug. 10, 1933, pp. 159–160. Foundation of 6-story loft building in St. Paul, Minn., settles dangerously because wood borers eat wood piles out from under wall and column footings; evidence on dry-wood borers.

HYDRO-ELECTRIC POWER PLANTS

TUNNELS. Ueber den Bau des Schluchseewerkes, R. Leonhardt. *Zement*, vol. 22, no. 32, Aug. 10, 1933, pp. 447–450. Construction of Schluchsee hydro-electric power plant in the Black Forest which will be the largest pump-storage plant in Germany; structural details of power tunnels with a total length of 6,100 m, with special reference to methods of concrete construction.

INLAND WATERWAYS

RIVERS, IMPROVEMENT. New Plans for Mississippi. Recent Investigations of Bank Revetment. *Eng. News-Rec.*, vol. 111, no. 6, Aug. 10, 1933, pp. 166–169. Report of underwater survey of existing revetment; submerged groins inadequate; hot-mix asphalt mats laid successfully; riprap revetment tests indicate practicability of certain types; types of submerged groins constructed for experimental purposes on shallow stable bank and deep caving bank; cost of mattress for revetment; agencies affecting revetment.

IRRIGATION

ITALY. L'impianto idroelettrico e di'irrigazione di Mazze Canavese della Cassa di Risparmio di Torino. V. Crotto. *Energia Elettrica*, vol. 10, no. 8, Aug. 1933, pp. 650–657. Further description of irrigation structures and irrigable lands of project; agricultural results of irrigation.

WYOMING. Power and Irrigation Work Financed by PWA. *Eng. News-Rec.*, vol. 111, no. 9, Aug. 31, 1933, pp. 251–253. Outline of irrigation and hydro-electric power developments in Wyoming, financed by allocation of $22,700,000 of federal funds of Public Works Administration; Seminole reservoir will be formed by concrete gravity dam of 277-ft maximum height; Casper-Alcova project for irrigation of 66,000 acres will include earth and rock-fill dam of 235-ft maximum height; reservoir operation; interstate problems.

MATERIALS TESTING

PHOTO-ELASTICITY. An Application of Interference Fringes to Stress Analysis, M. M. Frocht. *Franklin Inst.—Journal*, vol. 216, no. 1, July 1933, pp. 73–89. Principles of photo-elasticity and history of its application to study and determination of stresses; possible applications of elastic interference-fringe-stress patterns to test for isotropic and singular points and determination of formation of plastic regions.

PORTS AND MARITIME STRUCTURES

CRANES, CARGO. Zur Wahl einer Kranbauart in Hafen, Theuser. *Werft Reederei Hafen*, vol. 14, no. 15, Aug. 1, 1933, pp. 212–214. Selection of crane suitable for harbors; illustrated examples of different types of cranes and their relative merits.

DOCKS, SOUTHAMPTON. Southampton's New Graving Dock. *Civ. Eng. (London)*, vol. 28, no. 326, Aug. 1933, pp. 289–292. Detail of structure, 1,200 ft long, 135 ft wide, and 45 ft deep, described in several previously indexed articles.

FRANCE. 1,148-Ft Lock at St. Nazaire. *Engineering*, vol. 136, no. 3527, Aug. 18, 1933, pp. 165 and 166. Exceptionally large lock completed on French Atlantic seaboard; lock is closed at both ends by sliding caissons 51.6 m wide, 16 m high, and 8.9 m thick; caissons are moved into and out of recesses by means of articulated toothed racks, one of which is fixed on either side; it has already been used as a drydock for the new liner *Normandie*.

GREAT BRITAIN. Southern Railway's Southampton Docks Extension and World's Largest Graving Dock. *Ry. Gaz.*, vol. 59, no. 4, July 28, 1933, pp. 130–139, supp. plates. Brief history and strategic importance of Southampton Docks; latest extensions include a new quay wall 7,500 ft in length, reclamation of mud flats to form docks and industrial sites, dredging new deep water channel, and construction of graving dock.

JETTIES. Jetty Maintenance at Mouth of Columbia, R. E. Hickson. *Military Engr.*, vol. 25, no. 143, Sept.-Oct. 1933, pp. 411–414. Repair of old rock jetty at mouth of Columbia River; constructing approach tramway; placing new rock; specifications for stone; equipment and methods; cost of work is $1,286,600.

ROCK REMOVAL. Rock Removal in San Francisco Bay, H. S. Pond. *Western Construction News and Highways Bldr.*, vol. 8, no. 13, July 1933, pp. 322–324. Method of removing subsurface rocks, dangerous to navigation, in the Port of San Francisco; Blossom Rock and Rincon Reef Rocks cleared to 40 ft; Arch Rock, Shag Rocks No. 1 and 2, and Harding Rock cleared to 35 ft at mean low water; drill boat; dredge; derrick barge; drilling and blasting; soundings.

SLIPWAYS. Les slipway de 650 tonnes, a garages rayonnants, du port de pêche de Lorient. *Génie Civil*, vol. 103, no. 10, Sept. 2, 1933, pp. 221–225. Design, construction, equipment, and operation of repair shipyard in the fishing port of Lorient, France; fishing craft, up to 650 tons, is pulled up an inclined plane on to a turntable, 44.8 m in diameter, from which it may be shunted to one of ten repair docks, ranged in circumference around the turntable.

ROADS AND STREETS

ARGENTINE. Argentine Highway Program, L. A. Brookover. *Military Engr.*, vol. 25, no. 143, Sept.-Oct. 1933, pp. 403–406. Outline of recently approved development program to be spread over 15 years and to comprise about 18,000 miles of highway.

CALIFORNIA. California Adds 6,800 Miles to State Highway System. *Eng. News-Rec.*, vol. 111, no. 11, Sept. 14, 1933, p. 325. Statute places important county roads under state control and provides direct aid to municipalities from state gasoline tax; allocation of funds for primary and secondary routes made more flexible.

CONCRETE. Tests of Aggregate Interlock at Joints and Cracks, A. C. Benkelman. *Eng. News-Rec.*, vol. 111, no. 8, Aug. 24, 1933, pp. 227–232. Michigan concrete pavements under load tests indicate general effectiveness of aggregate interlock in transferring shear and value of reinforcement in increasing bond of cracks and joints.

CONSTRUCTION. Influence of Depths of Cuts on Highway Excavating Costs, H. K. Church. *Contractors and Engrs. Monthly*, vol. 27, no. 2, Aug. 1933, pp. 19–22. Study of 60 road projects; excavating equipment; dipper shovel performance; skimmer shovel performance; handling rock; analyzing depths of cuts; interpretation of analysis; percentage of total roadway excavation according to depth of cut.

CURVES. Banking Highway Curves, W. B. Potter. *Eng. News-Rec.*, vol. 111, no. 11, Sept. 14, 1933, p. 327. Discussion of the movement of automotive vehicles around curves, with special reference to incidence and severity of accidents.

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Experimental. Tests on Concrete Roads. *Concrete and Constr. Eng.*, vol. 28, no. 8, Aug. 1933, pp. 461–465. Review of experimental research on Harmondsworth experimental road, Hampton Court-Esher road, and Deatherhead by-pass road; cores from concrete roads.

Low-Cost. Progressive Low-Cost Road Construction, A. J. Moynihan. *Pub. Works*, vol. 64, no. 8, Aug. 1933, pp. 10 and 12. Review of modern methods available for low-cost improvement of thousands of miles of existing stone and gravel highways in the United States; surface treatments; mixed-in-place surfaces; pre-mixed surfaces; seal coats.

Maintenance and Repair. Current Practice in Resurfacing Old Pavements with Concrete. *Eng. and Contract Rec. (formerly Contract Rec.)*, vol. 47, no. 29, July 19, 1933, pp. 695–698. Survey of resurfacing projects; current practice in resurfacing design. From report of Am. Road Bldrs.' Assn. Committee on Reinforced Concrete Pavements.

Materials, Calcium Chloride. Calcium Chloride as Binder on Sand-Clay and Gravel Roads, L. L. Bateman. *Am. City*, vol. 48, no. 9, Sept. 1933, pp. 41–44. Experience of Huron County, Michigan. Delivered before Annual Conference on Highway Eng.

Railroad Crossings, Elimination. Complete Grade Separation Project at Birmingham, Ala. *Ry. Age*, vol. 95, no. 8, Aug. 19, 1933, pp. 271–275. Track elevation permits conversion of station of Louisville and Nashville Railroad to two-level type; project includes the installation of an interlocking plant which controls movements over crossing as well as 26 switches in adjacent trackage; map and profile of track elevation; particulars of construction and underpasses.

Roadside Improvement. Engineering Aspects of Roadside, R. A. Ryves. *Surveyor*, vol. 84, no. 2170, Aug. 25, 1933, pp. 161 and 162. Review of British practice as to trees and shrubs, trees and safety, footways, side ditches, and catch-water ditches.

Street Lighting, Posts. Concrete Lamp Standards. *Surveyor*, vol. 84, no. 2166, July 28, 1933, p. 76. Description of hollow centrifugally cast reinforced concrete lamp-post up to 13.25 ft in height.

Surface Treatment. Road Surface Dressing Developments, A. C. Hughes. *Surveyor*, vol. 84, no. 2168, Aug. 11, 1933, p. 127. Various modifications that have been adopted in connection with surface dressing since that process came into use, following the introduction of mechanically propelled vehicles; early difficulties; tar viscosities; gritting materials; man versus machine; use of bitumen.

SEWERAGE AND SEWAGE DISPOSAL

Assessments. Assessing for Storm Sewers, C. V. Davis. *Pub. Works*, vol. 64, no. 8, Aug. 1933, pp. 21 and 22. Review of methods of determining storm sewer assessments; legal decisions regarding benefits; tangible special benefits; calculation of assessments; sufficiency of storm drainage.

China. Modern Methods Employed in Sewage Treatment at Shanghai, W. Buchler. *Mun. Sanitation*, vol. 4, no. 8, Aug. 1933, pp. 260–264. Progressive improvement of sewage system; sludge dried on sand beds; pumps used for trench dewatering; concrete pipe made at municipal plant.

Coke Plants, Waste Liquors. Toxicity of Coke Oven Effluents, B. A. Southgate. *Gas World*, vol. 99, no. 2557, Aug. 5, 1933, p. 18. Discussion by A. Parker, of paper previously indexed from various sources.

Disintegration. Sewage Disintegration Before Discharge Into Sea, H. R. Homewood. *Surveyor*, vol. 84, no. 2167, Aug. 4, 1933, pp. 101 and 102 (discussion) p. 110. Description and method of operation of mechanical disintegrators developed at Bournemouth, England, which break up sewage solids and prevent fouling of beaches in the vicinity of sewer outfalls; costs. Before Inst. Mun. and County Engrs.

Filters, Cleaning. Achorutes Viaticus, G. MacLeod Ross. *Royal Engrs.—Journal*, vol. 47, Sept. 1933, pp. 492–494, 1 supp. plate. Cleaning of clogged sewage filter, at a small fraction of the cost of mechanical cleaning, by inoculation of filter beds with insects known as "achorutes viaticus," having particular affinity for fungus responsible for clogging bacterial filter beds.

Great Britain. Sewage Disposal at Sheffield. *Surveyor*, vol. 84, no. 2166, July 28, 1933, pp. 93 and 94. Description of new Woodhouse Mill unit of the City of Sheffield, for bio-aeration treatment of sewage, costing £36,000; water circulation in aeration tank; sludge digestion.

Industrial Wastes. Effects of Trade Effluents on Sewage Purification, C. C. Beedham. *Surveyor*, vol. 84, no. 2164, July 14, 1933, pp. 41 and 42. Practice of the Sewage Department of Bradford, England; Bradford sewage effluents; treatment of wool-scouring effluents; chemical precipitations; sludge disposal; pressing.

Oregon. Willamette Valley Sanitary Program Outlined in Report. *Eng. News-Rec.*, vol. 111, no. 11, Sept. 14, 1933, pp. 322 and 323. Sewage-disposal plants for important Oregon area containing 64 per cent of state population outlined by engineering board as the first step in the coordinated public-works program.

Sewers, Design. Rainfall as Affecting Flow in Sewerage Systems, C. C. Judson. *Surveyor*, vol. 84, no. 2168, 2169, and 2170; Aug. 11, 1933, pp. 119 and 120; Aug. 18, pp. 141–143; and Aug. 25, pp. 163–165. Discussion of principal rainfall factors; area of watershed; intensity of rainfall; time of concentration; area-time diagrams; methods of calculating run-off; author's method; possible economies.

Sludge. Artificial Heating and Circulation of Digesting Sludge. *Surveyor*, vol. 84, no. 2164, July 14, 1933, p. 39. English abstract of paper by Fracke, previously indexed from *Gesundheits-Ingenieur* June 10, 1933.

Tunnels, Lining. Uses 359,800-Sq Ft Clay Liners for Intercepting Sewer, G. E. Edgerton. *Brick and Clay Rec.*, vol. 82, no. 6, June 1933, pp. 201 and 202. Intercepting sewer, to collect sewage formerly discharged into river along Iowa shore of Lock and Dam No. 15 located in the Mississippi River, and discharge below dam; many special shapes used; forms used; setting of tile.

United States. Sewage Disposal Methods, G. Fuller. *Surveyor*, vol. 84, no. 2169, Aug. 18, 1933, p. 150. Abstract of paper previously indexed from *Water Works and Sewerage*, Feb. 1933.

Wilmington, Del. From Disposal by Dilution to Separate Sludge Digestion. *Am. City*, vol. 48, no. 9, Sept. 1933, pp. 45 and 46. Description of first separate sludge-digestion sprinkling-filter sewage treatment plant capable of handling wastes from population of 5,000; built by Wilmington, Del.

STRUCTURAL ENGINEERING

Brick. Interim Report on Bearing Pressures on Brickwork. *Structural Engr.*, vol. 11 (New Series), no. 9, Sept. 1933, pp. 379–385. Report of Masonry Sectional Committee on the effect of providing one or more courses of blue bricks to carry reaction at bearing of steel beam on brick wall.

Floors, Design. Strength of Flat-Arch Clay Tile Floor Construction, G. E. Large and C. T. Morris. *Brick and Clay Rec.*, vol. 83, no. 3, Sept. 1933, pp. 88 and 89. Abstract of paper previously indexed from Ohio State University—Eng. Experiment Station Series—Bul. no. 78, July 1933.

Joints, Wooden. New Connectors Strengthen Wood Joints. *Ry. Eng. and Maintenance*, vol. 29, no. 6, June 1933, pp. 281–283. Similar description previously indexed from U.S. Dept. of Commerce—Nat. Committee on Wood Utilization, 1933.

Riveted Joints, Design. Eccentrically Loaded Rivet Groups, W. G. Sutton. *Structural Engr.*, vol. 11 (New Series), no. 9, Sept. 1933, pp. 366–369. Standard method of calculation; use of standard types of connections.

Walls, Brick. Reinforced-Brick Walls Reduce Steelwork, L. B. Lent. *Eng. News-Rec.*, vol. 111, no. 9, Aug. 31, 1933, pp. 257 and 258. Functional shortcomings of pre-fabricated wall sheets; wall functions are analyzed and reinforced-brick walls shown to meet all requirements with the same degree of economy; suggested design of reinforced-brick wall.

TUNNELS

Belgium. Les tunnels pour véhicules et Piétons sous l'Escaut à Anvers, P. Calfas. *Génie Civil*, vol. 103, nos. 5 and 6, July 29, 1933, pp. 101–107 and Aug. 5, 137–139. Paper on the construction of vehicular tunnels under the Scheldt River at Antwerp, Belgium, similar in content to several articles on the same subject indexed in *Engineering Index* of 1932 and 1933.

Construction. Well-Managed Tunneling Methods Whip Low Contract Price. *Eng. News-Rec.*, vol. 111, no. 11, Sept. 14, 1933, pp. 310–314. Quick methods of construction of 10.6-mile tunnel, 11 ft by 12 ft 9 in. in cross section, leading from the Quabbin Reservoir to the Boston Metropolitan aqueduct; construction plan; excavation; muck disposal; concrete production; lining operations.

Great Britain. New Jersey Tunnel and Improved Roadways, J. A. Brodie. *Surveyor*, vol. 84, no. 2164, July 14, 1933, pp. 49–51. Report on the construction of an iron-lined tunnel under the river Mersey at Liverpool; internal diameter of 44 ft; described in several previously indexed articles; features of work; tunnel lining; use of shield; carriageway; lighting; ventilation; improved arterial roadways; 50-mile trunk highway. Before Inst. Mun. and County Engrs.

Japan. Tanna Tunnel, W. H. Clarke, Jr. *Far Eastern Rev.*, vol. 29, no. 5, May 1933, pp. 204–220. Construction of railroad tunnel, 25,614 ft long; details of cross sections to accommodate one or two railroad tracks; geology of tunnel site; combating floods, soft ground, and other troubles.

Railroad, Lining. Small Shield-Driven Tunnel Lined with Trapezoidal Blocks. *Eng. News-Rec.*, vol. 111, no. 6, Aug. 10, 1933, pp. 162 and 163. Description of interlocking precast units of new shape used in 4-ft drainage tunnel 170 ft long, under Pennsylvania Railroad tracks at Norristown, Pa.; blocks made on job in hydraulic press having a capacity of 400 blocks per day; shield design; tunnel driving; placing blocks.

Water Supply Construction. Construction of Cobble Mountain Diversion Tunnel, H. H. Hatch. *New England Water Works Assn.—Journal*, vol. 47, no. 2, June 1933, pp. 133–152. Construction of Springfield, Mass., waterworks and power supply tunnel 1,550 ft long, having horseshoe cross section 11 ft 6 in. high and 11 ft 6 in. wide; driving tunnel; drilling and shooting schedule for various tunnels; heading and bench methods; methods of sinking and raising shaft; lining and grouting tunnel; cost of grouting; tunnel appurtenances; cost data.

WATER TREATMENT

Analysis. Chloride and Sulfate in Rain Water, W. D. Collins and K. T. Williams. *Indus. and Eng. Chem.*, vol. 25, no. 8 (Indus. Edition), Aug. 1933, pp. 944 and 945. Results of the study of over 200 samples of rain water from several places in the United States examined, in U.S. Geological Survey, for chloride and sulfate. Bibliography.

Boulder City, Nev. Worst Water in West Made Fit to Drink, D. M. Forester. *Eng. News-Rec.*, vol. 111, no. 10, Sept. 7, 1933, pp. 275–279. Treatment of silt-laden Colorado River Water for builders of Boulder Dam, involving all the problems of pre-sedimentation, aeration, softening, recarbonation, filtering, and chlorination; desert cloudburst causing turbidity of 150,000 conquered with lime and carbonation; chemical changes during softening process; results obtained at pre-sedimentation clarifier; recirculation of sludge.

WATER WORKS ENGINEERING

Boston, Mass. Progress on New Water Supply for Metropolitan Boston. *Eng. News-Rec.*, vol. 111, no. 11, Sept. 14, 1933, pp. 308 and 309. Development by Metropolitan District Water Supply Commission, including 24.6-mile aqueduct tunnel, diversion tunnel, and two large earth dams with pneumatic-caisson corewalls; project taps Ware and Swift rivers in central Massachusetts.

Distribution Systems, Milwaukee, Wis. Storage Tank Operation to Aid Pressure Conditions, E. F. Tanghe. *Eng. News-Rec.*, vol. 111, no. 11, Sept. 14, 1933, pp. 321 and 322. Elevated tanks in Milwaukee boost pressures during summer peak loads, due to afternoon sprinkling, thereby saving installation of excessive pumping equipment.

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